THE

MODERN GEOMETRICAL

STAIR-BUILDER'S GUIDE,

BEING A

PLAIN PRACTICAL SYSTEM OF HAND-RAILING,

EMBRACING ALL ITS NECESSARY DETAILS,

AND

Geometrically Illustrated by Twenty-two Steel Engravings.

TOGETHER WITH THE USE OF

THE MOST IMPORTANT PRINCIPLES OF PRACTICAL GEOMETRY.

BY

SIMON DE GRAFF, ARCHITECT.

PHILADELPHIA:
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PREFACE.

To a work intended for those wishing to obtain a thorough knowledge of the Science of Geometrical Hand-rails and Stairs much preface is unnecessary. Although few subjects have of late years more employed the minds of men of science and builders than that of the art and science of hand-railing, the art of forming hand-rails around circular, oval, and excentric well-holes without the use of a cylinder is of recent date. The first successful method of squaring a wreath rail upon geometrical principles was invented by Mr. Peter Nicholson. Subsequent writers have contributed nothing towards the advancement of this most useful branch of the Builder's profession;—and have contented themselves with methods laid down by Mr. Nicholson, which were not advantageous, by not being carried out fully, and in many instances were uncertain in their application owing to the workman not being able to comprehend them fully, and which consequently led to erroneous results in the practice. The methods laid down by the author in this work are more simple and comprehensive than those used by Mr. Nicholson, whose diagrams are so loaded with operative lines, that it has a tendency to confuse the mind of the learner and give him a disgust in pursuing the study of the science. No previous author seems to have had any idea

of describing more than one section in a quadrant of a circle. The methods herein laid down by the author are entirely new and of his own invention; being founded upon geometrical principles, and carried out fully, they admit of two or more sections in the quadrant as the case requires, by which principle the workman will perceive that he may execute the work more expeditiously and require nearly one-half less in the quantity of stuff for the rail than by the methods laid down by previous authors.

Since the first invention of these methods by the author, they have been thoroughly tested both by theory and practice; and, therefore, this most essential branch as here presented is correct. The attention of the student is particularly directed to the arrangement of the plates, and by closely examining them with the help of their explanations, he will soon discern the utility of this work, and make himself master of the art and science, and also acquire a thorough knowledge of the principles and use of practical geometry, so far as is applicable to geometrical rails and stairs.

THE

STAIR-BUILDER'S GUIDE.

INTRODUCTION.

HAND-RAILING.

THE art and science of Hand-railing is to find the position of the section of the given plan, and to form the mould according to that position.

GEOMETRICAL STAIRS.

As every mansion consisting of more than one story is indebted to this portion of architecture for ornament and utility, the height of the Riser, and breadth and length of the Tread, should be governed by its location. The height of the Riser should not exceed eight inches, nor less than six and a half inches. The width of the Tread should not exceed fifteen inches, nor less than ten inches. The width of the Winder upon the concave end should be equal to one-half the width of the Flyer, which gives a graceful form to the Stairs.

The Student will observe, that by applying to plate No. 22, he may there obtain the use of the most important principles of Geometry practically illustrated, as far as is applicable to the art and science of Hand-railing.

In conclusion—This subject having been presented to the public nearly three-fourths of a century, and different methods having been adopted for the purpose of simplifying the matter, by subsequent writers, who were not successful by not

understanding its principles fully, both theoretically and practically, so as to make it comprehensive and advantageous to the learner, the author has laid down in this work the principles by which the moulds and easings are executed for the formation of the rail in practical size (see Plates 6, 7, 8), and manner of producing the butt-joint at any given point in the circle, also the manner of producing the formation of the solid section and spring moulds for each respective section, by which method the rail may be wrought out of the least possible stuff and with much less labor, and give it a more beautiful appearance by the grain of the wood keeping the circle of the rail—subsequent writers having been governed by the termination of the quadrant for the location of the joint, which necessarily required nearly double the quantity of stuff for the rail than the method herein adopted. The author having devoted much time in expounding this matter, both theoretically and practically, for the benefit of practical builders, and feeling confident of its correctness, beauty, and simplicity, and from the facilities which this work will afford, and the low price at which it is offered, feels assured that it will meet with the approbation and patronage of an enlightened public.

With these considerations this work is respectfully submitted by their

Humble Servant,

THE AUTHOR.

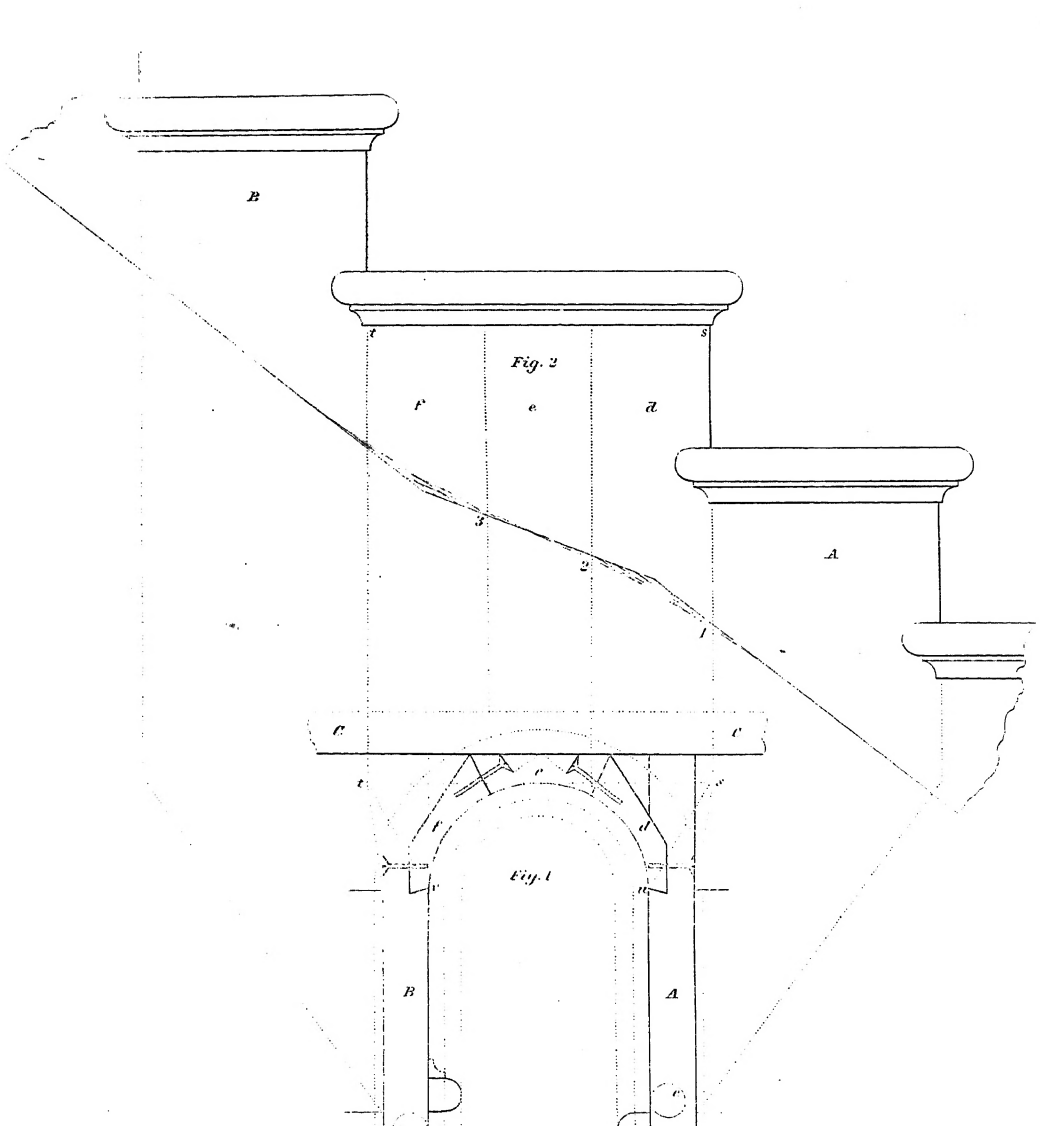

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PLATE 1.

Shows the plan and elevation of a cylinder stairs, running from the rake to the landing and landing to the rake.

Fig. 1 being the plan of the cylinder. *d e f* the staves, being glued and screwed together, which form the cylinder. *A* and *B* being the front strings, are glued and screwed to the cylinder. *C C* the front joist of the platform, against which the lower and upper flight rest. *s t* being the stretch-out* of the concave semi-circumference from *u* to *v*. *c c* the baluster. *o o* the line of the nosing; and *d e* the rail. It will be observed that the rail *D E* projects, over the face of the stringpieces *A* and *B*. The projection is obtained in the following manner:

Suppose the width of the rail to be - - - - - - -	3 inches,
from which take the size of the baluster, at the base, which being -	1¾ "
leaves 1¼ inches, which being divided by two - - - - - -	2)1¼ "
gives ⅝ of an inch for the projection of the rail, - - - - -	⅝ "

It is always necessary to ascertain the projection of a circular part of the rail before commencing to draw the plan for executing the moulds. If brackets are used, ascertain the projection from the line or face of the bracket.

Fig. 2 shows the elevation of the given place, fig. 1, which should be drawn upon pasteboard to obtain the length of the staves, and formation of the easings; then

* Which is produced in the same manner as in Plate 2.

applying it to the concave side of the cylinder (which is then merely screwed together), trace out the line of the easing. The workman will find great convenience in working the bead facie or moulding upon the lower edge of the cylinders before gluing the staves together, for then he may work from both ways, whereas, if it was glued together before working it would be more difficult, particularly in those small openings. To draw the elevation and stretch-out of fig. 2 from the stretch-out *s t* of the semi-circular part, fig. 1, erect perpendiculars to *s t* or under edge of the nosing of the platform; then *s t* will be the length of the concave semi-circumference of the cylinder. It is necessary to know the width of the front joist of the platform, against which the cylinder rests, before the length of the staves can be obtained. Apply the width of the joist to the stretch-out, or centre of the cylinder of the plan, fig. 2, allowing it to be ¼ of an inch longer to receive the lath and plastering; then from the under edge of the nosing at *s* set down the width of a riser; and at *t* set up the same. The depth of the stringpieces in the centre of the tread at *A* and *B* being obtained from the depth of the centre of the cylinder, then draw the hypothenuse of the lower edge of the string *A*, upwards to the centre of the stave *d*; also of *B* downwards to the centre of the stave *f*. Then connect the points *d* and *f*, which allow the centre of the cylinder to retain its given depth, and by intersecting lines each side of the angles, the easing will be formed, and the length of the staves *d e* and *f* may be obtained from the nosing to the points 1, 2, and 3, which completes the given plan.

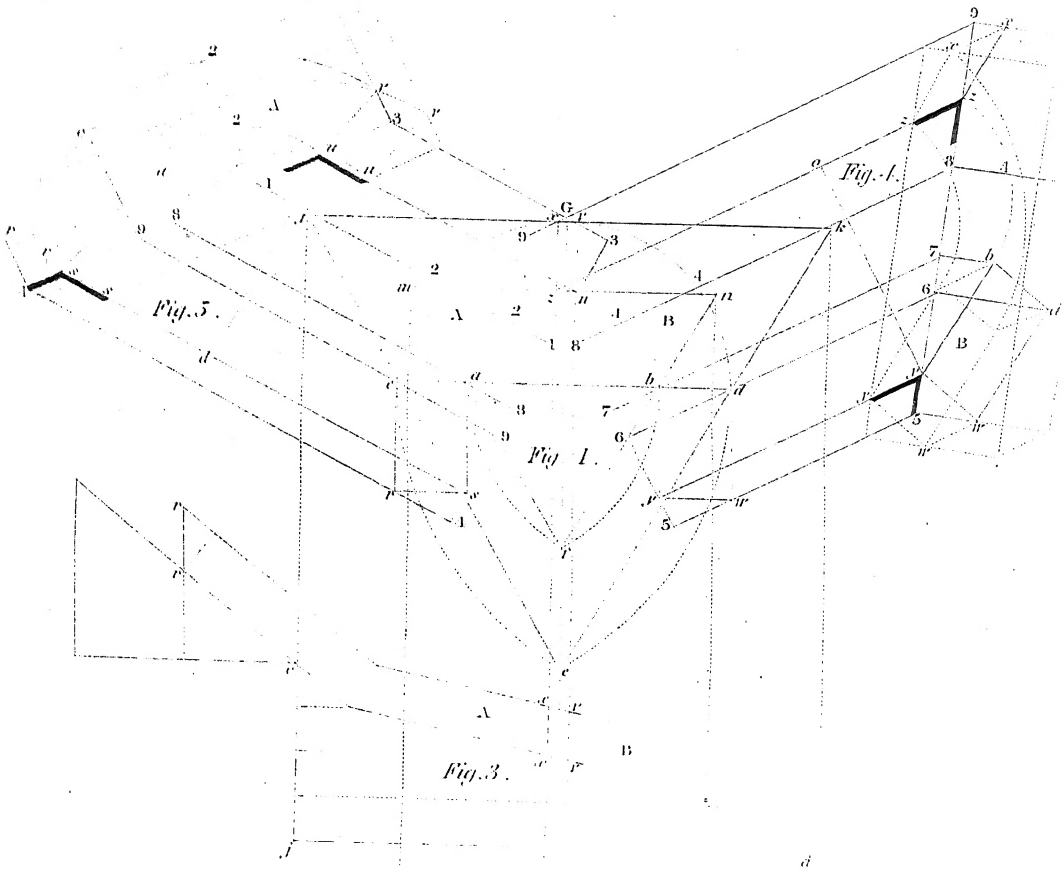


Fig. 1.

Fig. 4.

Fig. 5.

Fig. 3.

Fig. 2.

Scale

PLATE 2.

Shows the manner of obtaining the points, and drawing the lines for the formation of the face, and falling moulds, for a continued rail over a small opening.

A B, fig. 1, being the given plan of the semi-circular part, having a portion of straight rail attached. With the diameter *a b* of the concave, and *c d* of the convex sides of the plan for radii, and from the points *a b c* and *d* describe arcs intersecting at *e* and *f*; draw the tangent lines *m n* and *j k* (parallel to the diameter *a b* and *c d*) to the concave and convex sides of the given plan; from the point *f* draw lines through *a* and *b* intersecting the concave tangent at *m* and *n*, also from the point *e* draw lines through *c* and *d* intersecting the convex tangent at *j* and *k*; then *j k* and *m n* will be the stretch-outs or length of the concave and convex semi-circumference from *a b* to *c d* of the given plan.

To obtain the concave falling mould, fig. 2, from the given plan, fig. 1.

Draw the horizontal line *m b* and make it equal in length to the concave stretch-out *m n*, fig. 1. At the point *b* place the pitch board *b r n*; let *m a* be equal to the height of a rise, and divide it into four equal parts. Draw the first and third parts parallel to *m b* to obtain the points *x* and *e*. At the points *a* and *b* place the pitch board *a j l* and *b r n*; then draw the hypothenuses *j e*, *e x* and *x v*, set up the width of the mould which is equal to the required thickness of the rail, and draw said lines for the upper edge parallel to the lower edge of the mould; then apply the length of the straight parts *s a* and *y b* of the given plan, fig. 1, to the base of the upper and lower pitch board from *n* to *h* and *a* to *f*; erect the perpendiculars *h y* and *f s* to the

upper edge of the mould, and from *y* to *v* and *s* to *q* square across the mould; then the line *v y* and *s q* will be the given joints for the upper and lower ends of the mould. To obtain the joint in the centre of the semi-circular part, let fall the line *G H* perpendicular to the given plan, passing through the centre of the concave and convex falling moulds; obtain the centre of the mould upon the said perpendicular from *t* to *t*, and through it square across the mould from *z* to *u* and the line *z u* will be the required joint. Draw the lines *u u* and *z z* parallel to said perpendicular, and *u t* and *z t* will be the required overwood. Apply the overwood to each side of said perpendicular upon the given plan, fig. 1. Draw the lines *c o* through *v*, and *z d* parallel to *b m*, and *o z* and *d s* will be the heights for the parts *B* and *A* of said mould. To form the easings each side of the angle at *x*, divide *x v* and *x u* into six equal parts each, and from the point of division next the angle *x* on one side, draw a line to that point which is farthest from the angle *x* on the other side. Do the same from all the other parts of division, and by the intersection of those lines, the easings will be formed. The same distances are applied on each side of the angle at *e*. The easings being reversed to the one at *x*, the easing when formed at the upper edge of the mould should coincide with the lower edge, and then the mould will be of equal width and completed.

The convex falling mould, fig. 3, is obtained in the same manner as the concave at fig. 2.

Let *j d*, the base, fig. 3, be equal to *j k*, the stretch-out, fig. 1, of the convex side of the given plan, *j c* is equal to the height of a rise *d w*, and *c r* equal to the portions of straight rail as in fig. 2. The distances from each angle and point of division are obtained in the same manner as at fig. 2 for the formation of the easing. Then obtain the necessary overwood from the joint *z u*, fig. 2, and apply it upon each side of said perpendicular, as is shown at *x x* and *v v*. It will be perceived that the two falling moulds, figs. 2 and 3, have different angles of inclination, and that the lines of the overwood *v v* and *x x* of the convex are shorter than *u u* and *z z* of the concave. There will be no difficulty arising from the difference, as will be seen by the cutting of the joint of the rail pieces.

How to obtain the face moulds, figs. 4 and 5, from the given plan, fig. 1.

At the part *B* of the given plan, fig. 1, draw the chord line 5 9 touching the concave points at *y z*, including the overwood of the quadrantal part *B*. Erect perpendiculars from said chord line at 5, *y*, 6, 7, 8, *z*, and *q*; through the points *w*, *d*, *b*, and *x*, draw *o y* parallel to the chord line; then obtain the height *o z*, fig. 2, and apply it upon the perpendicular, from the parallel at *o* to *z*. Draw the hypothenuse 9 5 touching the point *z*, also the parallel at *y*; at the angles *z y* of the hypothenuse to the perpendicular, is the pitch bevel obtained. Draw lines at right angles to the hypothenuse, from the points 5, 6, 7, 8, 9; then obtain the several distances 5 *w*, 6 *d*, 7 *b*, 8 4 4, and 9 *x*, from the chord line, fig. 1, and apply them upon the perpendicular, *s*, to the hypothenuse, fig. 4, from the points 5, 6, 7, 8, and 9, to *w*, *d*, *b*, 4, 4, and *x*. Draw the lines *x z*, which will be the end of the required mould. The points *z* 4 *b* and *x* 4 *d* being obtained, describe the arcs through them, and *b y* and *d w* will be the length of the straight part, and *y w* the end of the required mould. The face mould at fig. 5 is obtained in the same manner as at fig. 4; the straight part being thrown up, and the height from the parallel line at *d* to the hypothenuse at *s* being obtained at *d s*, fig. 2.

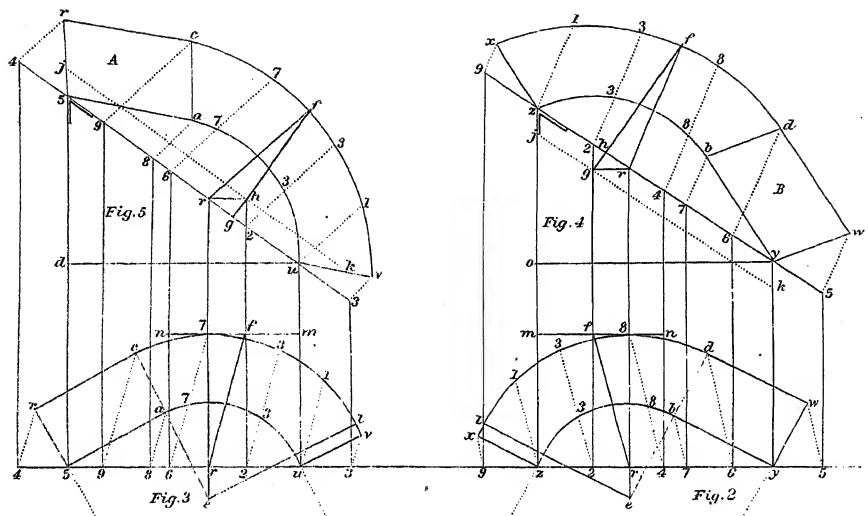
The diagram *B* and *A*, figs. 4 and 5, gives a full description of the manner in which the face moulds are applied to both sides of the plank.

From the parts *z* and *y*, fig. 4, and *u* and *s*, fig. 5, at the upper edge of the plank, the pitch bevels being obtained and applied across to the lower edges *z y*, fig. 4, and *u s*, fig. 5, which give the angle of inclination to the rail-pieces. Then tracing the line of the moulds on both sides of the plank, and cutting away the superfluous wood to the line of the moulds, the rail-pieces thus formed are ready for the application of the parts *B* and *A* of the concave and convex falling moulds. Take the part *B*, fig. 2, of the concave falling mould (which is supposed to be made of pasteboard), and apply it to the concave edge of the rail-piece at fig. 4, having the plumblines *z z*, of the overwood, fig. 2, applied to the lines of the pitch bevel *z z* and *y y*; then bend the mould to the inner edge of said rail-piece, and the plumbline *y y* of said mould will coincide with the line *y y* of the pitch bevel. Then mark the joints *y v*

and *u z*, and on the upper edge at *y*, and the lower edge at *z* of said joints, square across the ends of said rail-piece.

In the same manner apply the part *B*, fig. 3, of the convex mould, having the plumblines of overwood *x x* and *w w* to coincide with *x x* and *w w* of the convex edge of the rail-piece; and when the lines are thus squared across the end from the concave to the convex edge, let the points of said mould at *x* of the lower, and *w* of the upper edge, rest. Then trace out the line of the moulds, and cutting away the superfluous wood to them, and the butt joints being cut, the rail-piece thus formed will range over its plan.

The upper wreath at *A*, fig. 5, being formed in the same manner as *B*, fig. 4, with the part *A*, fig. 2, of the concave mould being applied to the concave edge of the rail-piece, having the plumblines *u u* and *s s* of said mould to coincide with the pitch bevel *u u* and *s s* of said rail-piece. In the same manner the convex part *A*, fig. 3, being applied to the convex edge, with the plumblines *v v* and *r r* of said mould, coinciding with *v v* and *r r* of said rail-piece; the butt-joints being obtained and cut, the line of the mould being traced, the superfluous wood cut away, and the rail-pieces dowled and well screwed together, are then ready for moulding.



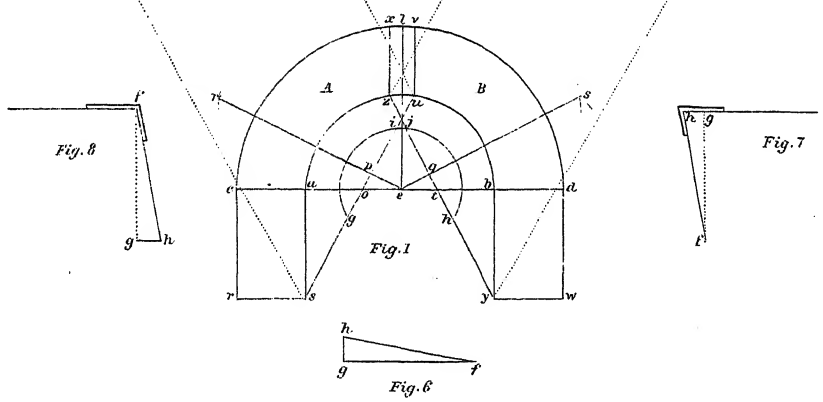


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PLATE 3.

Shows the manner of obtaining the points, and drawing the lines for the formation of the face moulds for the lower and upper wreaths of Plate 2, when the edge of the plank forms an acute angle, out of which the lower wreath is formed, also when the edge of the plank forms an obtuse angle, out of which the upper wreath is formed, which is usually termed the spring of the plank, and the manner in which the quadrantal parts, figs. 2 and 3, are thrown from the quadrantal parts, B and A, fig. 1.

REFERENCES TO FIGURES AND LETTERS.

Fig. 1, *A B* the given plan of the cylinder, *a b* the diameter of the concave, and *c d* of the convex sides of the plan for radii, having *e* as centre, then *e d* and *e l* be the radius of the quadrantal part, *B*, and *z x* the line of overwood, *b y* and *d w* the length of the straight part, *z y* the chord-line. To erect the perpendicular *s* to the chord *z y*, from the centre *e*, set the point of the dividers in the centre at *e*, and describe the arc *j h* upon the chord *z y*, then set the point of the dividers at *j* and *h*, and describe the arcs at *s*, and at the point where the arcs bisect at *s* draw the line *e s*, then *e s* will be the perpendicular to the chord *z y*. The points in the quadrantal part *A* are obtained in the same manner. Then draw the base line 4 and 5 of figs. 2 and 3 parallel to the base *c d* of the semi-circular part *A B*, fig. 1; then erect the perpendiculars *e r* from the base 5 9 and 3 4 of figs. 2 and 3; then take the distance upon the perpendiculars *s r*, fig. 1, from the chord-lines *q* and *p* to the centre *e*, and apply it upon the perpendiculars from the base at *r*, figs. 2 and 3, to *e*, then *e* will be the centres for figs. 2 and 3. Then take the distance *q t* and *p o* upon the chord-lines from the perpendiculars *s r*, fig. 1, to radius *e d* and *e c* of each respective quadrant,

and apply said distance upon the base from *r*, towards 4, fig. 2, also from *r* towards 6, fig. 3; then through said points from *r*, upon the base of figs. 2 and 3, draw the radius from the centre *e* to *b d* and *a c;* then draw the radius *e l* of figs. 2 and 3, at right angles to *e b d* and *e a c;* then take the distance in the dividers, from the centre *e*, fig. 1, to *a* or *b* of the concave, and *c* or *d* of the convex, and apply said distance from the centre *e*, fig. 2, to *b* and *d*, and describe the arcs *b z* of the concave, and *d x* of the convex; the line *z y* will be the required overwood. Let *b y* and *d w* be equal to *b y* and *d w*, fig. 1, then *z x* and *y w* will be the ends of the quadrantal part of the given plan, fig. 2; also apply said distance from the centre *e*, fig. 3, to *a* and *c*, and describe the arc *a u* of the concave, and *c v* of the convex, the line *u v* will be the required overwood; let *a* 5 and *c r* be equal to *a s* and *c r*, fig. 1, and *u v* and 5 *r*, will be the ends of the quadrantal part of the given plan, fig. 3. The object of throwing up the quadrantal parts, figs. 2 and 3, from the parts *B* and *A*, fig. 1, is because in drawing the plan for the rail full size of a circular stairs, the workman may find it difficult to obtain sufficient room for executing the moulds for the same; therefore, by throwing up the quadrantal part or segment in a more convenient place, the mould may be executed with exactness.

Fig. 6, *f h g* forms a right angled triangle—the distance *f h* is equal to 2 *f*, of figs. 2 and 3, from the chord-lines *z y* and *u* 5, to the parallel lines *m n* and *n m*, and is obtained from the same, whether quadrantal or segment. The distance *g h* is to give the angle of inclination to *h f;* the distance *g h* may be greater or less as the case may require; if thin stuff the greater the distance, if thick stuff the less distance is required—in figs. 7 and 8 they are equal.

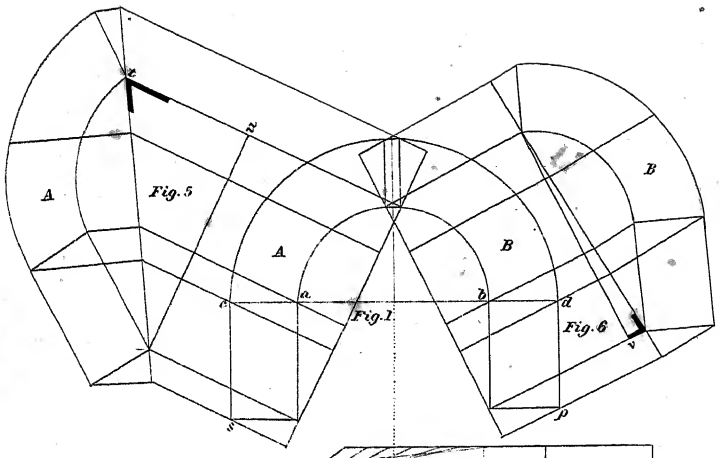
Fig. 7 shows the manner of forming an acute angle from *f h g*, fig. 6, or bevel for the edge of the plank, from which the lower wreath is formed.

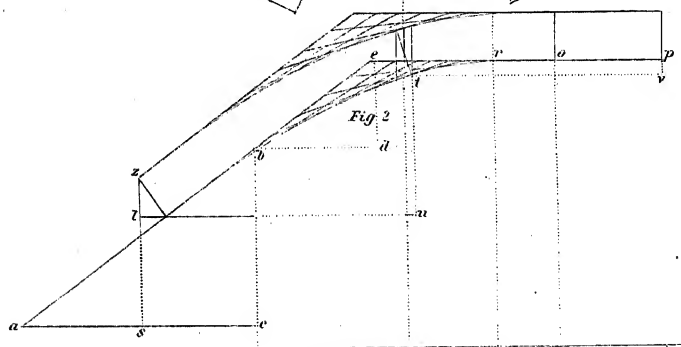
Fig. 8 shows the manner of forming an obtuse angle from *f h g*, fig. 6, or bevel for the edge of the plank, from which the upper wreath is formed.

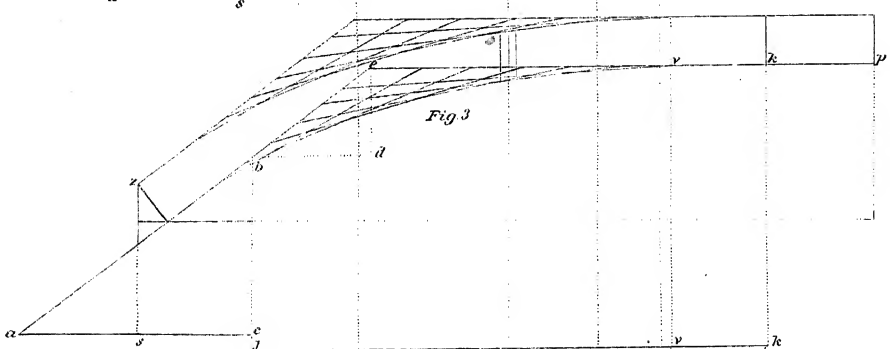
Fig. 4 shows the manner of forming the face mould for the spring of the plank, when the upper side and edge of the plank form an acute angle as at fig. 7, for the lower wreath, from the quadrantal part, fig. 2; first erect the perpendiculars *z* and *y*, from the chord-line, fig. 2; then draw *o y* parallel to the chord *z y*, and take the height *o z*, fig. 2, Plate 2, and apply it from the parallel at *o*, to *z*, fig. 4, Plate 3; then draw the hypothenuse *z y*, through to 5 9. At the angle *z* of the perpendicular to the hypothenuse is the pitch-bevel obtained. Draw the dotted line *j k*, parallel to the hypothenuse, let its distance from the hypothenuse be equal to *h g*, fig. 6, or *h g*, fig. 7; then erect the perpendicular *r r*, from the chord, fig. 2, to the hypothenuse, fig. 4; draw *r g*, parallel to the chord, let fall the perpendicular 2 2, from the hypothenuse to the chord, cutting the point *g* of *r g*, then draw *m n*, fig. 2, parallel to the chord *z y*, cutting the convex side of the quadrantal part of the given plan; draw the diagonal line *r f*, from the chord *z y*, to the parallel *m n;* then draw the dotted lines parallel to *f r*, from the several points upon the quadrantal part, to the chord commencing at *w* 5, *d* 6, *b* 7, 8 8 4, 3 3 2, 1 *z*, and *x* 9;. then erect perpendiculars from the several points upon the chord line, 5, 6, 7, 4, and 9, to the hypothenuse, 5, 6, 7, 4, and 9, of fig. 4; then from the angle at *g*, erect *g h f*, perpendicular to the hypothenuse 5 9; let the distance *h f* be equal to 2 *f*, fig. 2, from the chord *z y*, to the parallel *m n;* then from the angle at *r*, upon the hypothenuse, draw the diagonal *r f;* then draw the dotted lines parallel to *r f* from the several points, as 5, 6, 7, 4, 2, *z*, and 9, upon the hypothenuse; then take the several distances from the chord, fig. 2, upon the dotted lines, 5 *w*, 6 *d*, 7 *b*, 4 8 8, 2 3 3, *z* 1, and 9 *x*, and apply them from the hypothenuse, fig. 4, upon the dotted lines, 5 *w*, 6 *d*, 7 *b*, 4 8 8, 2 3 3, *z* 1, and 9 *x;* draw *x z* and *w y*, then *x z* and *w y* will be the ends of the required mould; draw *y b* and *w d*, which are the required straight part. The points being obtained, describe the arc *z b* for the concave side through the points 3 8, also the convex *x d*, through the points 1 3 8, which completes the face moulds for the lower wreath.

Fig. 5 shows the manner of forming the face mould to the spring of the plank, when the upper side and edge of the plank form an obtuse angle as at fig. 8. For the upper wreath from the quadrantal part, fig. 3, first erect the perpendiculars 5 *u*,

from the chord-line, fig. 3; then draw *d u* parallel to the chord 5 *u*, and take the height *d s*, fig. 2, Plate 2, and apply it from the parallel at *d* to 5, fig. 5, Plate 3; then draw the hypothenuse 5 *u* through to 3 4, at the angle 5 of the perpendicular to the hypothenuse is the pitch-bevel obtained. Draw the dotted line *j k* parallel to the hypothenuse, let the distance from the hypothenuse be equal to *g h*, fig. 6, or *g h*, fig. 8; then erect the perpendicular *r r*, from the chord, fig. 3, to the hypothenuse, fig. 5, draw *r h* parallel to the chord from the hypothenuse to the parallel or dotted line *j k* to the chord 5 *u*, let fall the perpendicular *h* 2, draw *m n*, fig. 3, parallel to the chord 5 *u*, cutting the concave side of the quadrantal part of the given plan; draw the diagonal line *r f*, from the chord 5 *u*, to the parallel *n m*, then draw the dotted lines parallel to *f r*, from the several points upon the quadrantal part to the chord, commencing at *r* 4, *c* 9, *a* 8, 7 7 6, 3 3 2, 1 *u*, and *v* 3; then erect perpendiculars from the several points upon the chord-line 4, 9, 8, 6, and 3, to the hypothenuse 3, 6, 8, 9, and 4 of fig. 5; then through the angle *h* erect *g f*, perpendicular to hypothenuse 3 4, let the line *g f* be equal in length to 2 *f*, fig. 3, from the chord 5 *u* to the parallel *n m;* then from the angle at *r*, upon the hypothenuse, draw the diagonal *r f*, then draw the dotted lines parallel to *r f*, from the several points 3, *u*, 2, 6, 8, 9, and 4, upon the hypothenuse; then take the several distances from the chord, fig. 3, upon the dotted lines 4 *r*, 9 *c*, 8 *a*, 6 7 7, 2 3 3, *u* 1, and 3 *v*, and apply them from the hypothenuse, fig. 5, upon the dotted lines 4 *r*, 9 *c*, 8 *a*, 6 7 7, 2 3 3, *u* 1, and 3 *v*, draw *v u*, and *r* 5; then *v u*, and *r t*, will be the ends of the required mould. Draw 5 *a*, and *r c*, which being the required straight part, the points being obtained, describe the arc *u a* for the concave side, through the points 3, 7, also the convex *v c*, through the points 1, 3, 7, which completes the face mould for the upper wreath.







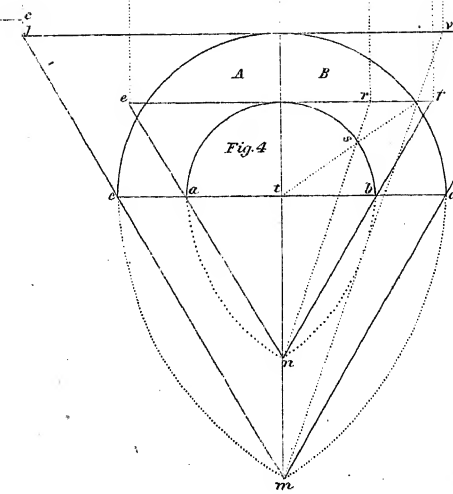


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PLATE 4.

Shows the manner of drawing the lines for the formation of the face and falling-moulds of a stair-rail easing over a small opening in the landing.

Let *A B*, fig. 1, be the semi-circular part of the given plan, having a portion of straight rail attached at each end. *A B*, fig. 4, shows the manner of obtaining the stretch-out of the semi-circular part. With *a b* and *c d*, the diameters of the concave and convex semi-circumference of the given plan *a b c* and *d* as centres, describe the arcs intersecting at *m* and *n;* then draw the tangent lines *e f* and *j k* of the concave and convex sides of the given plan. From the point *n* draw lines through *a* and *b*, intersecting the concave tangent at *e* and *f;* also from *m* draw lines through *c* and *d*, intersecting the convex tangent at *j* and *k;* then *j k* and *e f* will be the stretch-outs or lengths of the convex and concave semi-circumferences of *a b* and *c d*.

It will be observed that *A B*, fig. 4, is the same as the given plan, fig. 1, being drawn merely to show more clearly the manner of obtaining the different points and their stretch-outs.

To obtain the concave falling mould, fig. 2, from the concave stretch-out *e f*, fig. 4, erect perpendiculars from the points *e* and *f* of the concave stretch-out to *b* and *o;* at the point *b* place the upper angle of the pitch-board *a b c* and *b d*, the line of the floor; draw *d e* equal to half a rise at right angles to *d b*, then draw the hypothenuse *a e* and *e p* parallel to the stretch-out of the given plan, fig. 4. Let *o p* be equal to the straight part, *d p*, of the given plan, fig. 1. From the angle at *e* upon the hypothenuse measure off eight inches in length, which divide

into six equal parts. Then take the length of four of these parts and apply it upon the opposite side of the angle at *e* and divide said distance into six equal parts; then by intersecting lines the easing will be formed for the lower edge. Set up the width of the mould, square across it at each extremity of said easing, and from the points upon the upper edge of said mould the upper easing may be formed.

Take the length of the straight part *c s* of the given plan, fig. 1, and apply it upon the base of the pitch-board from *c* to *s*, fig. 2. Erect the perpendicular *s z*, and from *z* square across the moulds, which line will be the line of the required joint. The joint at *t* in the centre of the semi-circular part is obtained in the same manner as in the preceding plate. At *p* square across the mould, and this is the line of the terminating joint. Draw *l u*, touching the lower edge of the lower joint, and *u t* at right angles to *u l;* draw *t v* parallel to the lower edge of said mould, and *v p* at right angles to *v t;* then *u t* and *v p* will be the given heights for the upper and lower parts of said mould. The convex falling mould, fig. 3, is obtained in the same manner from *j k*, the convex stretch-out, fig. 4, as the concave mould fig. 2 was obtained from *e f*, the concave stretch-out, fig. 4.

To form the easing upon the convex falling mould, fig. 3, so that it may coincide with the concave easing, fig. 2, take the distance from *r* at the termination of the easing to *o* at fig. 2, and apply it upon the concave stretch-out from *f* to *r*, fig. 4; then draw the line *r n*, and through its intersection with the concave semi-circumference, draw *t s* from the centre *t* to the convex semi-circumference; then draw *m v* through its point of intersection with the convex semi-circumference, and *v k* will be the required distance. Apply said distance upon the mould from *k* to *v*, fig. 3. Divide the distance from *v* to the angle at *e* into six equal parts. The distance upon the hypothenuse from the angle at *e* is the same as upon the hypothenuse of the concave mould, fig. 2. Divide this distance into six equal parts, and by intersecting lines from those parts, the easing will be formed; then square across the mould at each extremity of the easing to the upper edge, where the easing is formed in the same manner as at the lower.

Then the convex easing will coincide with the concave when applied to the rail pieces, the overwood being obtained from each side of the perpendicular at the joint *t* of the concave falling mould, and applied to each side of said perpendicular upon the convex mould, fig. 3, also at the centre of the semi-circular part, fig. 1.

It will be observed that the manner of obtaining the lines and heights for the formation of the face moulds, figs. 5 and 6, the application of the face moulds to the plank, the cutting away of the superfluous wood, the application of the falling moulds to the rail-pieces, and the obtaining and cutting of the joints, are the same as has been described in the preceding plates.

Fig. 1

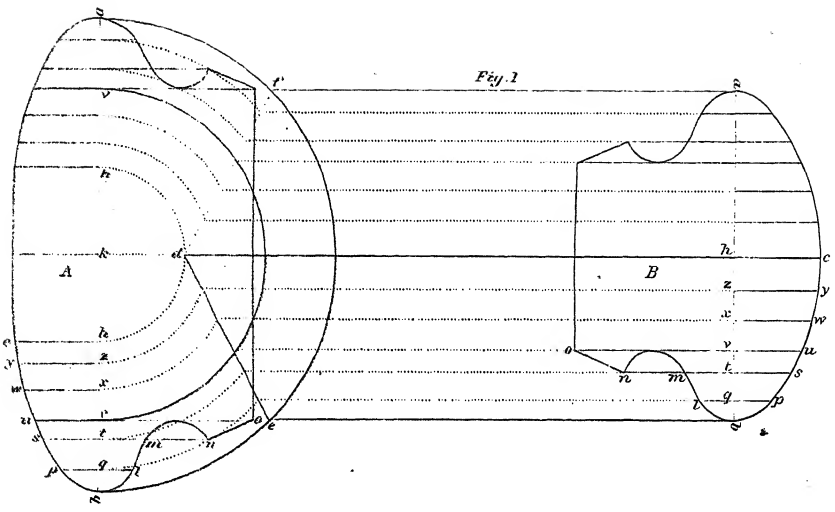

Fig. 2

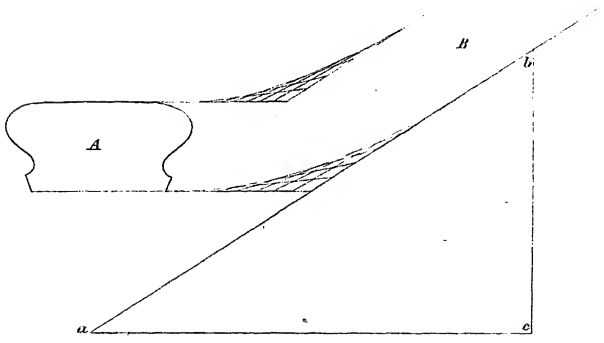

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PLATE 5.

The form of the rail being given to draw the mitre cap.

Fig. 1. Let *A* be the plan of the rail, and *B* the mitre cap. At *A* draw the line *a b* to obtain the width of the rail, and the line *o u* which shows the projection of the moulding of the rail. The width of the cap being obtained, draw the line *a b;* from the centre *k* describe the semicircle *a b*, then take the distance from *b* to *v* at *A*, being the projection of the moulding, and apply it to *b v* at *B*, then describe the semicircle *v v* and draw the lines *b e* and *a f*, also the centre line *h d*, and the mitre *e d* and *f a*. Divide the line *b h* at *A* into any number of parts, and draw the lines parallel to *b e* from the upper side of the rail through the points of division *z x v t g* to the mitre *e d*. Do the same upon the side *a h* to the mitre *f d;* then place the point of the compass at the centre *k* and circumscribe the parallel lines from the mitre *d e* around to *h z x v t* and *q* and draw the ordinates *h c*, *z y*, *&c.;* then prick the cap according to the letters. Perform the same from the mitre *d f* to *h a*, and then through the points trace out the cap.

Fig. 2. *Shows the manner of elevating the cap to its proper height when attached to the rail, also the formation of the easing.*

Let *a b c* be the pitch-board, *A* the cap and *B* the rail. The cap being raised equal to the height of half a riser, when placed upon the newel, will be equal in height to the rail placed upon the long balusters.

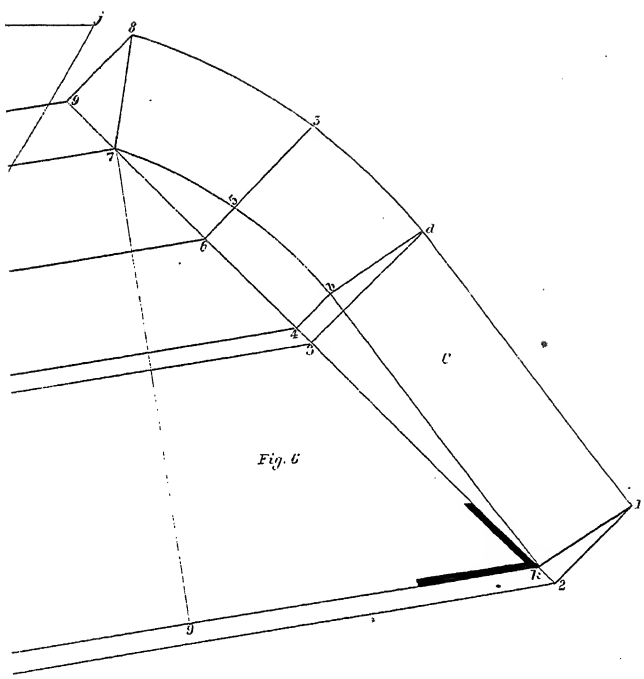

Fig. 6

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PLATES 6, 7, 8.

Show the manner of drawing the lines for the formation of the face and falling-moulds for the rail of a semi-circular stairs, having seven winders with fliers attached below, and easing over the landing above.

A, *B*, *C*, fig. 1, Plate 6, being the given plan of the rail, having a portion of straight rail attached to each end of the semi-circular part, with the diameter *a b*, of the concave, and *c d*, of the convex sides of the plan for radii, and from the points *a b* and *c d*, describe arcs, intersecting at *e* and *f*. Then draw the tangent lines, *g h* and *i j*, to the concave and convex sides of the given plan; then from the point *e*, draw lines through *a* and *b*, intersecting the concave tangent at *g* and *h*; also from the point *f*, draw lines through *c* and *d*, intersecting the convex tangent at *i* and *j*; then *g h* and *i j* will be the stretch-out, or length of the concave and convex semi-circumference from *a c*, to *b d*, of the given plan.

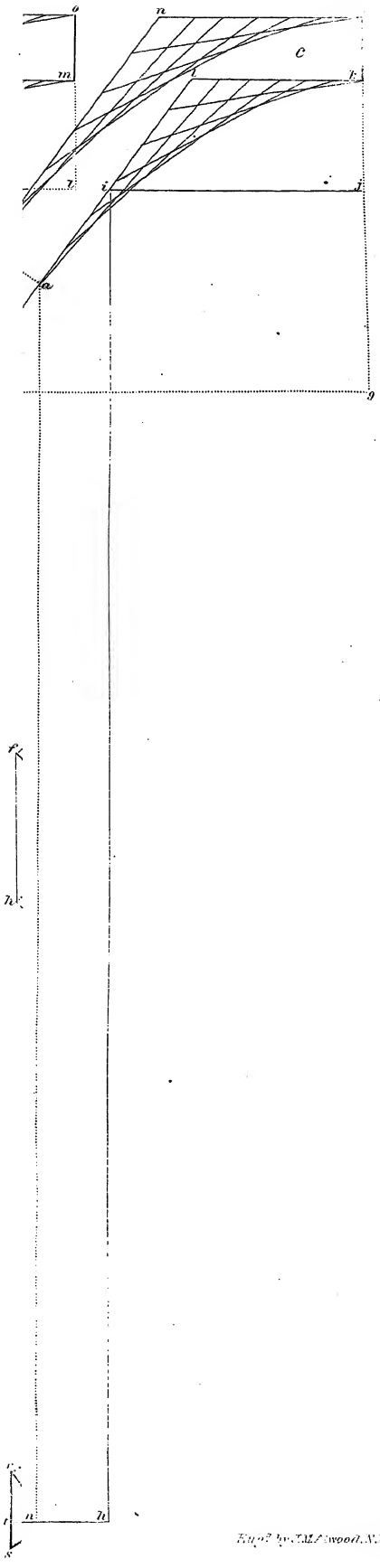

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PLATE 7.

To obtain the points for the formation of the concave and convex falling moulds, figs. 2 *and* 3, *from the given plan, fig.* 1, *of Plate* 6.

Draw the horizontal line *t h*, or base of the concave and convex falling moulds.

Fig. 2. Let *e f g* be the pitch-board, and *g h* be equal to the concave stretch-out, *g h*, fig. 1, Plate 6. Draw *h i*, the height-rod, perpendicular to *e h*, the base; draw *i j*, the line of the floor, which is equal in length to *b k*, fig. 1, Plate 6. Let *j k* be equal to the height of half a riser, which allows the rail on the landing, when placed upon the baluster, to have its proper height; then draw *k l* parallel to *j i*, draw the hypothenuse *l f*, touching the angle at *i*, and *f e*, to *g;* then set up the width of the mould, which is equal to the required thickness of the rail. Draw *p o*, *o n*, and *n m*, parallel to *k l*, *l f*, and *f q*, which gives the proper angle of inclination to said mould.

Fig. 3. Let *g h i* be the pitch-board, and *i j* be equal to the convex stretch-out, *i j*, fig. 1, Plate 6; then draw *j k* the height-rod (which is the same as at fig. 2) perpendicular to *g j*, the base, and *k l*, the line of the floor, which length is equal to *d* 1, fig. 1, Plate 6. Let *l m* be equal to the height of half a riser, which allows the convex mould to coincide with the concave; then draw *m e* parallel to *l k*, draw the hypothenuse, *e h*, touching the angle at *k*, and *h* g, to *s;* then set up the width of the mould, which is equal in width to fig. 2; draw *r q*, *q p*, and *p o*, parallel to *m e*, *e h*, and *h s*, which gives the proper angle of inclination to said mould.

To form the easing upon the concave falling mould, fig. 2.

Take the distance *e g*, or base of the pitch-board, and apply it from the angle at *f*, to *t;* let fall the perpendicular, *t*, to *s;* then on each side of the angle at *f*, divide *f t* and *f e* into six equal parts each, and from the point of division next to the angle on one side, draw a line to that point which is farthest from the angle, on the other side; then do the same from all the other points of division, and by the intersection of those lines, the easing will be formed for the lower edge of said part of the mould; then square across the mould at *e p* and *t u;* then from the angle at *o*, to *u*, and *o*, to *p*, divide *o p*, and *o u*, into six equal parts each, and by intersecting lines to each of those parts, at each side of the angle at *o*, the easing for the upper edge of said part will be formed, which completes the lower easing of said mould.

To form the upper easing of said mould.

The distance from the angle at *l* to *a* being equal to eight inches, divide said distance into six equal parts, and apply the distance equal to four of those parts, upon the opposite side of the angle, at *l*, to *k*, and divide said distance into six equal parts; then by the intersection of lines (as has been described) the easing will be formed for the lower edge of said part of the mould; then square across the mould at *a b* and *k m;* then from the angle *n* to *m*, and *n* to *b*, divide *n b*, and *n m*, into six equal parts each, and by intersecting lines to each of those parts, at each side of the angle at *n*, the easing for the upper edge of said part will be formed, which completes the upper and lower easings of said mould.

To form the easings upon the convex falling mould, fig. 3.

Take the distance upon the base *g s*, fig. 2, and apply it upon the concave stretch-out line from *g* to *s*, fig. 1, Plate 6, draw the dotted line *s e*, and at the intersection of *s e*, with the concave side *a b*, draw the dotted line from the centre *o*, through said point of intersection of the concave, to the convex side of the

given plan. Draw the dotted line *f u*, through said point of the convex side of said plan; then take the distance, *i u*, of the convex stretch-out, and apply it upon the base from *i* to *u*, fig. 3, Plate 7. At *u* erect a perpendicular from the base *i j*, and at the point in which this perpendicular intersects the lower edge of the convex mould at *v* square across at *v w*. The lower point of the easing being obtained at *g*, square across the mould at *g r;* then divide each distance on each edge of the mould, from each side of the angles at *h* and *q*, to *g r*, and *w v*, into six equal parts, and by the intersection of lines connecting those parts, the lower easing will be formed. Then take the distance upon the base line from *g* to the dotted line *n*, fig. 2, and apply it upon the concave stretch-out, from *g* to *n*, fig. 1, Plate 6; then draw the dotted line *e n*, and at the intersection of *e n*, with the concave side *a b*, draw the dotted line from the centre *o*, through said point of intersection of the concave to the convex side of the given plan. Draw the dotted line *f y* through said point of the convex side of said plan; then take the distance *i y*, of the convex stretch-out, and apply it upon the base line from *i* to *y*, fig. 3, Plate 7. At *y* erect a perpendicular from the base *i y*, to *c*, square across at *c d;* the upper point of the easing being obtained at *m*, square across at *m o;* then divide each distance on each edge of the mould, from each side of the angles at *e p*, to *m c*, and *o d*, into six equal parts, and by the intersection of lines connecting those parts, the upper easing will be formed, which completes the easings for the convex falling mould.

To obtain the butt-joints upon the concave falling mould, as at fig. 2, in Plate 7.

From the base, *g h*, erect as many perpendiculars as there are intended to be joints, as *v x*, through *d c* to *w y*, on the upper edge of said mould. (It should be observed that the number of pieces required to form the rail should be governed by the size of the opening or well-hole, that the grain of the wood may continue with the circle of the rail as near as possible, which gives the rail a more beautiful appearance, and is much stronger and requires much less stuff in thickness.) Then obtain the centres of the mould upon the part of the perpendiculars that pass through from *d* to *w* and *c* to *y*, which centres are 2 5; then square across the mould

at 1 3 and 4 6, passing through the centres 2 5; it being squared across at *k m*, the upper end, and *e p*, the lower end of said mould, then the lines *k m*, 4 6, 1 3, and *e p* are the given joints. To obtain the necessary overwood for each given joint, let fall the perpendiculars *p q*, 3 10, and 6 12; also erect the perpendiculars 1 11 and 4 13, to the base *r h;* then each respective distance (parallel to the base) as *r e*, 3 *w*, *w* 11, 6 *y*, and *y* 13, will be the required overwood for each respective joint. The joint *k m*, at the upper end of the mould, there being no overwood, for the reason that the joint is perpendicular to the base or floor line, *j i;* then take the distance *i j*, the floor line, and *r g*, the base of the pitch-board, including the overwood, *r e*, and apply said distances from the semi-circular part of the given plan, *a c* and *b d*, fig. 1, Plate 6, to 8 10 and *k* 1, which is the required portion of straight rail attached to each end of the semi-circular part.

The manner of obtaining the line of overwood upon the convex falling mould, fig. 3, *from the concave, fig.* 2.

Take the distances upon the base, *g v* and *g x*, fig. 2, and apply them upon the concave stretch-out line from *g* to *v* and *g* to *x*, fig. 1, Plate 6; then draw the lines *e v* and *e x*, and at the intersection of *e v* and *e x*, to the concave side, *a b*, draw the radius lines from the centre, *o*, through said point of intersection of the concave to the convex side of the given plan, and through said points of intersection to the convex side, *c d;* draw the lines *f x* and *f z*, then obtain the required overwood for each respective joint from the concave falling mould, fig. 2, as from 2 to the line 3 10, from 2 to 1 11, from 5 to 6 12, from 5 to 4 13, and apply it upon each side of the radius lines drawn from the centre *o*, fig. 1, as 7 10, 1 3, and 7 8, 4 3; then take the distance *i x* and *i z* from the convex stretch-out and apply them upon the base from *i* to *x* and *i z*, fig. 3, Plate 7; then from the base at *x* and *z* erect perpendiculars through to the upper edge of said mould to *b* and *a;* then let fall the perpendicular *r s*, then take the distance upon the base of the convex mould from *t* to *i*, *i* to *j*, and *k* to *l*, will be equal to the convex edge of the given

plan of fig. 1, Plate 6, from 10 to *c*, *c* round to *d*, and *d* to 1; also the distance upon the base of the concave mould, fig. 2, from *r* to *g*, *g* to *h*, and *i* to *j*, will be equal to the concave edge of the given plan of fig. 1, Plate 6, from 8 to *a*, *a* round to *b*, and *b* to *k*.

Figs. 4, 5 *and* 6, *of Plate* 6, *show the manner of obtaining the points for the formation of the face moulds A B and C, from the given plan, fig.* 1, *Plate* 6, *and from figs.* 2 *and* 3, *of Plate* 7.

Draw the chord line 9 2 of the part *A* of the given plan touching the concave points at 8 1; then erect perpendiculars from said chord line at 9 8 7 6 4 1 and 2 through the points 10 *c a* and 3; then draw 8 7 parallel to the chord line, then obtain the height, 7 1, of fig. 2, Plate 7, and apply it upon the perpendicular from the parallel at 7 to 1, fig. 4, Plate 6, draw the hypothenuse 2 9, touching the point at 1 and the parallel at 8; at the angle at 1 of the hypothenuse to the perpendicular, is the pitch bevel obtained; draw lines at right angles to the hypothenuse from the points 9 7 6 4 and 2, then obtain the several distances 9 10, 7 *c*, 4 5 5, and 2 3 from the chord line, fig. 1, and apply them upon the perpendiculars to the hypothenuse, fig. 4. From the points 9 7 6 4 and 2, to 10, *c*, *a*, 5 5, and 3, draw the lines 1 3, *a c*, and 8 10, then 1 3 and 8 10 will be the ends of the required mould. The points 1 5 *a* of the concave and 3 5 *c* of the convex part, *A*, being obtained, describe arcs through them, draw *a* 8 and *c* 10, then *a* 8 and *c* 10 will be the length of the straight part, and 8 10 the end of the required mould. Draw the chord line 9 2 of the part *B* of the given plan, touching the concave points at 7 4; then erect perpendiculars from said chord line at 9 7 5 4 and 2, through the points 10 and 3; then draw 7 8 parallel to the chord line, then obtain the height, 8 4, fig. 2, Plate 7, and apply it upon the perpendicular from the parallel at 8 to 4, fig. 5, Plate 6; draw the hypothenuse 2 9, touching the point at 4 and the parallel at 7. At the angle 4 of the hypothenuse to the perpendicular is the pitch bevel obtained. Draw lines at right angles to the hypothenuse from the points 9 5 and 2, then obtain the several

distances 9 10, 5 6 6, and 2 3, from the chord line, fig. 1, and apply them upon the perpendiculars to the hypothenuse, fig. 5, from the points 9 5 and 2 to 10, 6 6, and 3; draw the lines 4 3 and 7 10, which lines will be the ends of the required mould. The points 4 6 7 of the concave and 3 6 10 of the convex part, *B*, being obtained, describe arcs through them. Draw the chord line 9 2 of the part *C* of the given plan, touching the concave points at 7 *k*, then erect the perpendiculars from said chord line at 9 7 6 4 3 *k* and 2, through the points 8 *b d* and 1; then draw 7 9 parallel to the chord line, then obtain the height, 9 *k*, fig. 2, Plate 7, and apply it upon the perpendicular from the parallel at 9 to *k*, fig. 6, Plate 6, draw the hypothenuse 2 9, touching the point at *k*, and the parallel at 7. At the angle *k* of the hypothenuse to the perpendicular is the pitch bevel obtained. Draw lines at right angles to the hypothenuse from the points 9 6 4 3 and 2, then obtain the several distances 9 8, 6 5 5, 4 *b*, 3 *d* and 2 1 from the chord line, fig. 1, and apply them upon the perpendiculars, to the hypothenuse, fig. 6; from the points 9 6 4 3 and 2 to 8, 5 5, *b*, *d*, and 1, draw the lines *k* 1, *b d* and 7 8, then *k* 1 and 7 8 will be the ends of the required mould; draw the lines *k b* and 1 *d*, then *k b* and 1 *d* will be the length of the straight part required; the points *b* 5 7 of the concave and *d* 5 8 of the convex part *C* being obtained, describe arcs through them, which completes each respective face mould, *A B* and *C*, from the parts *A B* and *C* of the given plan, fig. 1.

PLATE 8.

Shows the manner of obtaining the points and drawing the lines for the formation of the face moulds to the spring of the plank (when the upper side and edge form an acute angle, as at A and B, and when the upper side and edge form an obtuse angle, as at C) from the given plan, fig. 1.

It should be observed that the given plan, fig. 1, Plate 8, is the same as the given plan, fig. 1, Plate 6; therefore it is unnecessary to describe them again, their stretch-outs being the same, and the manner of obtaining them; the location of the joints the same, the heights being obtained from fig. 2, Plate 7, for the formation of the face moulds. The student will at once discern the utility of forming the face moulds to the spring of the plank, from the same plan that the solid section is of Plate 6; that the governing principles of each may be more easily described, *A B* and *C*, fig. 1, being the given plan of the rail.

To form the face mould A, fig. 4, *to the spring of the plank (when the upper side and edge form an acute angle) from the part A of the given plan, fig.* 1.

Draw the chord line 9 2 (of the part *A* of the given plan) touching the concave points at 8 1; then erect the perpendiculars 8 1 from the chord line, then draw 7 8 parallel to the chord 9 2, and take the height, 7 1, fig. 2, Plate 7, and apply it upon the perpendicular from the parallel at 7 to 1, fig. 4, Plate 8; then draw the hypothenuse through 1 8; draw the dotted line *j k*, parallel to the hypothenuse, and let its distance from the hypothenuse be equal to *h g*, fig. 8; then erect the perpendicular *r r* from the chord-line to the hypothenuse, fig. 4, draw *r g* parallel to the chord; let

fall the perpendicular 11, 11, from the hypothenuse to the chord, cutting the point *g* of *r g;* then draw *n m* parallel to the chord 8 1, cutting the convex side of the part *A* of the given plan, draw the diagonal line *r f* from the chord to the parallel *n m;* then draw the dotted lines parallel to *f r*, from the several points upon the part *A* of the given plan to the chord, commencing at 10 9, *c* 7, *a* 6, 5 5 4, 11 12 12 and 3 2; then erect perpendiculars from the several points upon the chord-line 9 7 6 4 and 2, to the hypothenuse 9 7 6 4 and 2 of fig. 4; then from the angle at *g* erect *g h f* perpendicular to the hypothenuse 9 2, let the distance *h f* be equal to 11 *f*, from the chord 8 1 to the parallel *n m;* then from the angle at *r* upon the hypothenuse, draw the diagonal *r f;* then draw the dotted lines parallel to *r f* from the several points 9 7 6 4 11 and 2, upon the hypothenuse; then take the several distances from the chord upon the dotted lines 9 10, 7 *c*, 6 *a*, 4 5 5, 11 12 12 and 2 3, and apply them from the hypothenuse, fig. 4, upon the dotted lines 9 10, 7 *c*, 6 *a*, 4 5 5, 11 12 12 and 2 3 draw 1 3, *a c* and 8 10, then 1 3 and 8 10 will be the ends of the required mould; draw 8 *a* and 10 *c*, which being the length of the required straight part, the points being obtained, describe the arc *a* 1 for the concave side through the points 5 12, also the convex *c* 3, through the points 5 12, which completes the face mould *A*, fig. 4, from the part *A* of the given plan, fig. 1.

To form the face mould B, fig. 5, to the spring of the plank (when the upper side and edge form an acute angle) from the part B of the given plan, fig. 1.

Draw the chord-line 9 2 of the part *B* of the given plan, touching the concave points 7 4; then erect the perpendiculars 7 4 from the chord-line; then draw 8 7 parallel to the chord 9 2, and take the height 8 4, fig. 2, Plate 7, and apply it upon the perpendicular 4 4, from the parallel at 8 to 4, fig. 5, Plate 8; then draw the hypothenuse 2 9 through 4 7, draw the dotted line *j k* parallel to the hypothenuse, and let its distance from the hypothenuse be equal to *h g*, fig. 9; then erect the perpendicular *r r* from the chord-line to the hypothenuse, fig. 5, draw *r g* parallel to the chord, let fall the perpendicular 14 14 from the hypothenuse to the chord-line, cutting the point *g* of *r g;* then draw *n m* parallel to the chord 7 4, cutting the

convex side of the part *B* of the given plan; draw the diagonal line *r f* from the chord to the parallel *n m;* then draw the dotted lines parallel to *f r* from the several points of the part *B* of the given plan, to the chord, commencing at 10 9, 7 *o*, 1 *e*, 15 15 16, 6 6 5, 14 13 13, 11 11 12 and 3 2; then erect perpendiculars from the several points upon the chord-line, 9, *e*, 16, 5, 14, 12 and 2, to the hypothenuse 9, *e*, 16, 5, 14, 12 and 2 of fig. 5; then from the angle at *g*, erect *g h f* perpendicular to the hypothenuse 9 2, let the distance *h f* be equal to 14 *f*, from the chord 7 4 to the parallel *n m;* then from the angle at *r* upon the hypothenuse draw the diagonal *r f;* then draw the dotted lines parallel to *r f*, from the several points 9, 7, *e*, 16, 5, 14, 12 and 2 upon the hypothenuse; then take the several distances from the chord upon the dotted lines 9 10, 7 *o*, *e* 1, 16 15 15, 5 6 6, 14 13 13, 12 11 11 and 2 3, and apply them from the hypothenuse, fig. 5, upon the dotted lines 9 10, 7 0, *e* 1, 16 15 15, 5 6 6, 14 13 13, 12 11 11 and 2 3; draw 4 3 and 7 10, then 4 3 and 7 10 will be the ends of the required mould. The points being obtained, describe the arcs 7 4 for the concave side, through the points 1, 15 6, 13 11, also the convex 10 3, through the points *o*, 15 6, 13 11, which completes the face mould *B*, fig. 5, from the part *B*, of the given plan, fig. 1.

To form the face mould C, fig. 6, *to the spring of the plank* (*when the upper side and edge form an obtuse angle*) *from the part C of the given plan, fig.* 1.

Draw the chord-line 9 2 of the part *C* of the given plan, touching the concave points 7 *k;* then erect the perpendiculars 7 *k* from the chord-line; then draw 9 7 parallel to the chord 9 2, and take the height 9 *k*, fig. 2, Plate 7, and apply it upon the perpendicular *k k*, from the parallel at 9 to *k*, fig. 6, Plate 8; then draw the hypothenuse 2 9 through *k* 7, draw the dotted line *j k* parallel to the hypothenuse, and let its distance from the hypothenuse be equal to *g h*, of fig. 10; then erect the perpendicular *r r* from the chord-line to the hypothenuse, fig. 6, draw *r h* parallel to the chord, let fall the perpendicular *h s* from the hypothenuse to the chord-line; then draw *m n* parallel to the chord 7 *k*, cutting the convex side of the part *C* of the given plan; draw the diagonal *r f* from the chord to the parallel *m n;* then

draw the dotted lines parallel to *r f*, from the several points of the part *C* of the given plan, to the chord commencing at 8 9, *t* 4 *s*, 5 5 6, *b* 4, *d* 3 and 1 2; then erect perpendiculars from the several points upon the chord-line 9, *s*, 6, 4, 3 and 2, to the hypothenuse 9, *s*, 6, 4, 3 and 2 of fig. 6; then through the angle *h* erect *g f* perpendicular to the hypothenuse 7 *k*, let the line *g f* be equal in length to *s f* from the chord 7 *k* to the parallel *m n;* then from the angle at *r* upon the hypothenuse draw the diagonal *r f;* then draw the dotted lines parallel to *r f*, from the several points 9, *s*, 6, 4, 3 and 2, upon the hypothenuse; then take the several distances from the chord upon the dotted lines 9 8, *s* 4 *t*, 6 5 5, 4 *b*, 3 *d* and 2 1, and apply them from the hypothenuse, fig. 6, upon the dotted lines 9 8, *s* 4 *t*, 6 5 5, 4 *b*, 3 *d* and 2 1, draw 7 8, *b d* and *k* 1; then 7 8 and *k* 1 will be the ends of the required mould, draw *k b* and *d* 1, which being the required straight part, the points being obtained, describe the arcs 7 *b* for the concave side, through the points 4 5, also the convex 8 *d*, through the points *t* 5, which completes the face mould *C*, fig. 6, from the part *C* of the given plan, fig. 1.

Fig. 7 shows the manner of obtaining the proper angle of inclination to the edge of the plank, as *A*, *B*, *C*, of figs. 8, 9 and 10, from which the rail-pieces are formed, also from which the face moulds *A*, *B* and *C* of figs. 4, 5 and 6, obtain their proper position and form.

A, *B* and *C* of figs. 8, 9 and 10, shows the proper position of the plank, with their bevels attached for each respective mould. It is necessary to obtain the position or bevel for the edge of the plank, before executing the face mould, that its form may coincide with that position.

Fig. 4, Plate 7, gives a sectional view of the rail-piece; *A*, *A*, the face mould, also showing the manner of applying the face mould *A* of fig. 4, Plates 8 or 6, to the plank. *a b c d*, and *e f g h* being the ends of the plank, the lines *a e* and *c g* being the face edge of the plank, *a b* and *e f* the upper side, *c d* and *g h* the lower; the face mould being formed, apply the concave points of said mould to the face edge of the plank; then mark around the mould to obtain its form upon the upper side of the

plank; then obtain the pitch-bevel from the angle 1 of the perpendicular to the hypothenuse of fig. 4, Plates 8 or 6, and apply it to the edge of the plank, at the concave points of the mould 3 8; then mark the line of the bevel 3 3 and 8 8; then take the mould *A*, from the upper side and apply it to the under side of the plank, placing the concave points of the mould to the line of the bevel 3 8; then mark around the mould to obtain its form on the lower side of the plank—as is shown in the diagram; then cutting away the superfluous wood to the line of the mould of the concave side, from the bevel line 8 8 to 3 3, also to the convex side from 10 10 to 1 1; then cutting the ends of the rail-piece to the line from 8 10, 10 8, to 8, also 3 1, 1 3 to 3; then said rail-piece is ready for the application of the part *A* of the concave and convex falling moulds; apply the lower part of the concave falling mould *p q*, to the line of the bevel 8 8, fig. 4, and bending it to the concave edge of the rail-piece; then the line 1 11 of said mould will coincide with the line of the bevel 3 3; then mark the joints 1 3 of the upper end of the part *A*, also *e p* of the lower, and 1 of the upper ends of said mould, square across the ends of the rail-piece from the concave to the convex side, place the point *r* of the lower end of the convex falling mould, fig. 3, having the line *r s* upon the line 10 10, fig. 4, and bending it around the convex side of the rail-piece; then the line 1 11 of said mould will coincide with the line 1 1 of said rail-piece, and the point 1 of the convex falling mould, fig. 3, will rest upon the line squared across the end of said rail-piece, from the point 1 of the concave falling mould, fig. 2; then tracing the upper and lower edges of the part *A* of the concave and convex moulds upon the rail-piece; then cutting away the superfluous wood to the line of the moulds and joints, the piece thus formed will have its proper length, size and twist, and will range over its plan; also the parts *B* and *C*, figs. 5 and 6 of Plates 8 and 6, are applied in the same manner.

It should be observed that, let the moulds be formed for the spring of the plank, or solid section, also the pitch bevels, their application to the plank is the same as has been described in the part *A* of the given plan, fig. 4, Plate 7.

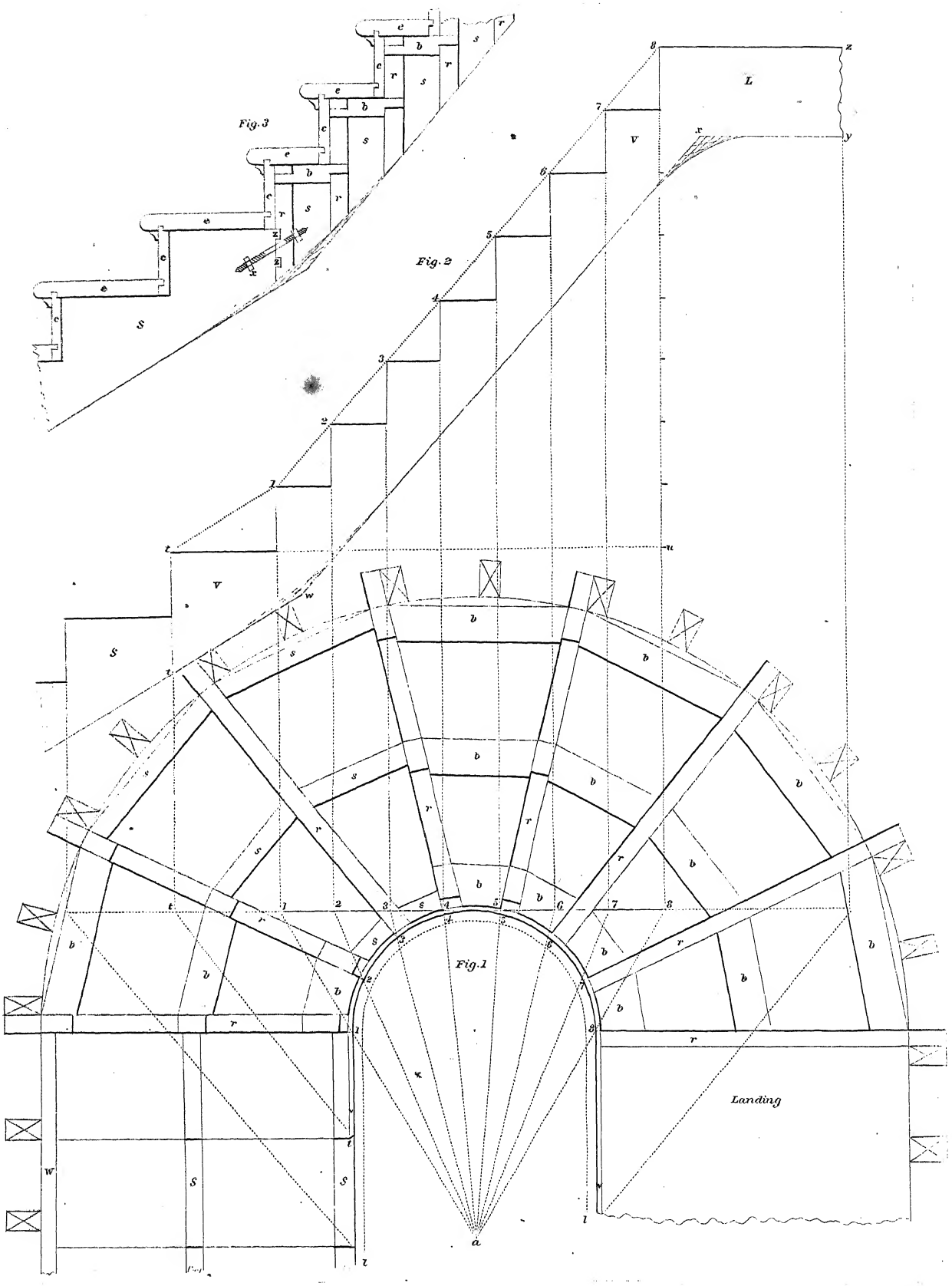

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PLATE 9.

Shows a practical method of executing the plan of the carriage of a geometrical stair, with seven winders, having fliers attached below, and resting against the landing above.

Fig. 1. Plan of the carriage from a bird's-eye view.

Fig. 2. Plan and elevation of the veneer.

Fig. 3. Plan and elevation of the concave side of the carriage.

References to letters in fig. 1.

S, S, The front and middle string, or carriages of the straight part.

W, The wall string or skirting for the straight part.

r r r r, Plank risers.

b b b, The bearings.

s s s, The staves or brackets; those upon the concave side of the carriage are formed to the circle.

v v, The veneer.

l l, Showing the projection of the concave side of the rail over the concave side of the carriage.

References to letters in fig. 2.

The stretch-out, 1 8 of the semi-circular part of the given plan, fig. 1, is obtained in the same manner as has been described in the preceding plates. Draw lines from

the centre *a* through the points 1 2 3 4, &c., to the tangent line 1 8, cutting the face edge of the plank risers *r r;* then from the points upon the tangent line erect perpendiculars through to the upper edge of *V V L*, of said veneer at *t*, 1 2 3 4, &c., to *z*, then draw the line *t u*, parallel to the tangent *t* 8. Divide *u* 8, the height rod, into the number of parts there are risers in the given plan, fig. 1; draw the floor line 8 *z;* then, at *z y*, set down the distance equal to the required width of the trimmer joist in the landing, then draw *y x*, *x w*, and *w t*, the lower edge of the veneer, the form of the easing being obtained in the same manner as has been described.* The line *t t* is the junction of *V*, the veneer, to *S*, the string.

References to letters in fig. 3.

S. The part of the front string.

z z. Tenons being formed upon the ends of the front string, and mortices formed into *r*, the first plank riser, for its reception.

x. The screw to connect the string to the winders.

r r r. Plank risers.

b b b. Bearers.

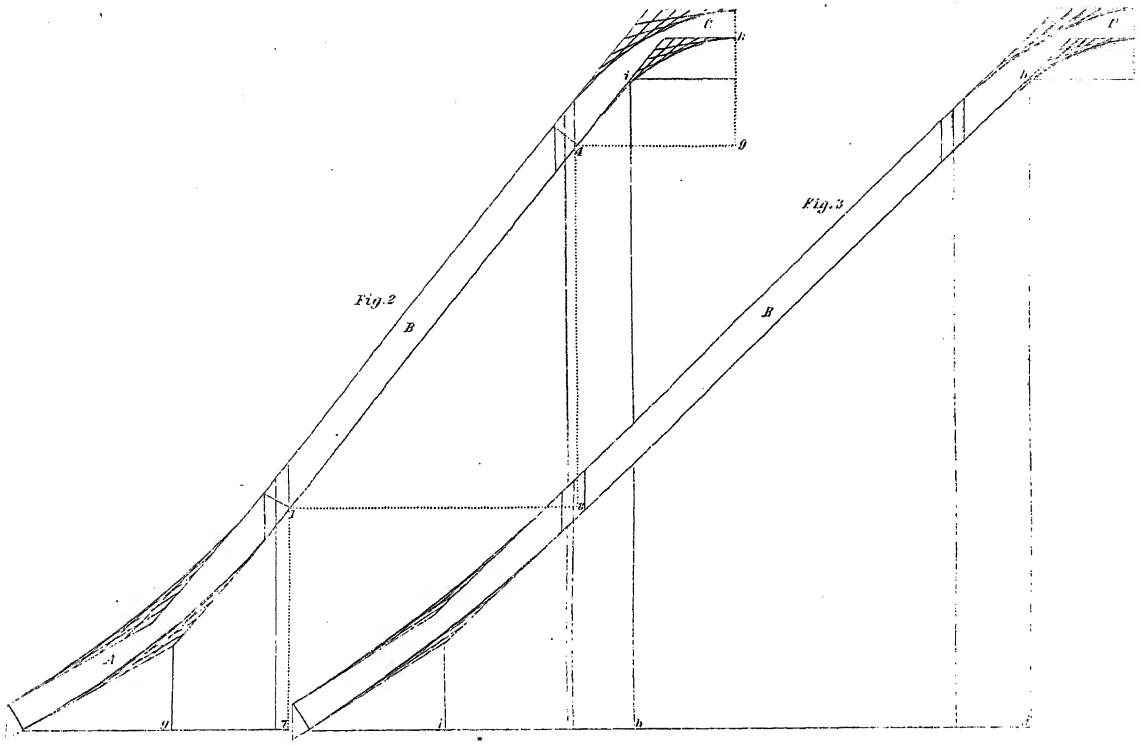
s s s. The staves or brackets which, being fitted, glued, and screwed, to the angles of the bearers and risers, the middle and back brackets are secured in the same manner, which answer for lathing joist under the carriage of the stairs.

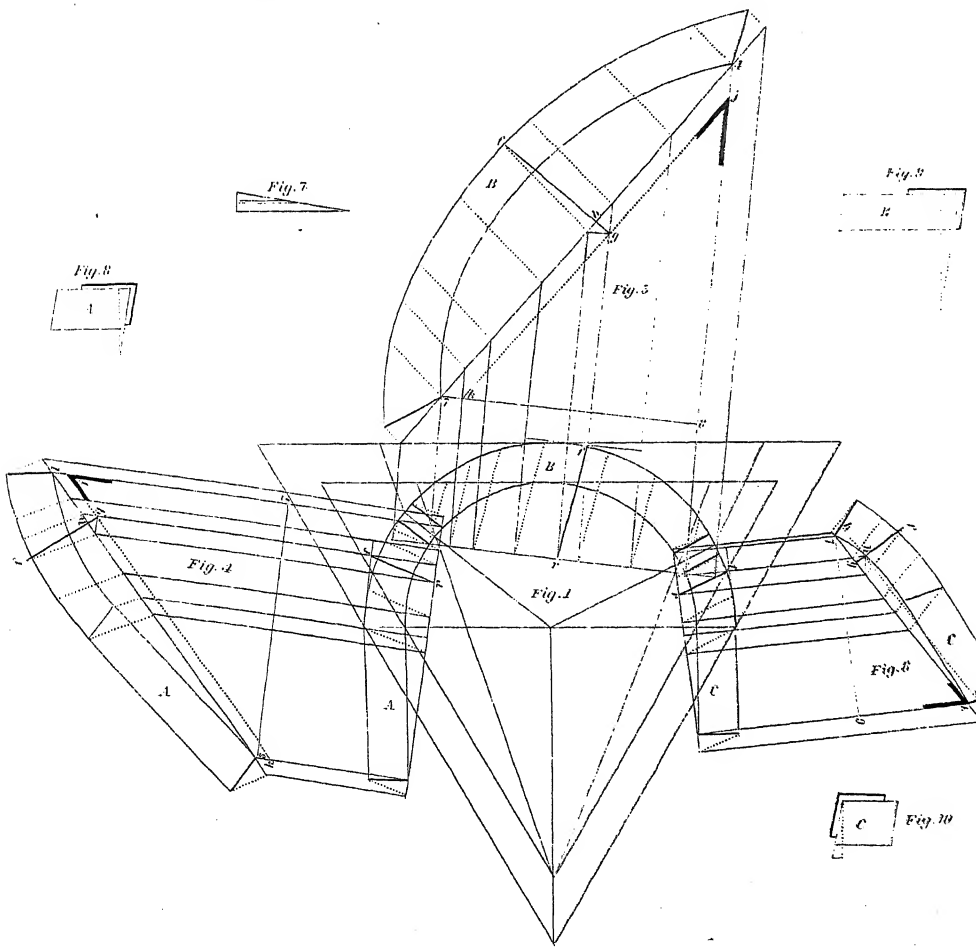
c c c. Risers.

e e e. Treads.

It should be observed that, let the well-hole have whatever form it may, the carriage may be formed upon this method.

* The bead being planted to the under edge of the veneer and concave string, for the reception of the lath and plastering.





P. Miller, Pr. Sculp.

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PLATE 10.

Needs no explanation: for it is the same as has been described in Plates 6, 7 *and* 8, *its size being drawn merely to coincide with the size of Plate* 9.

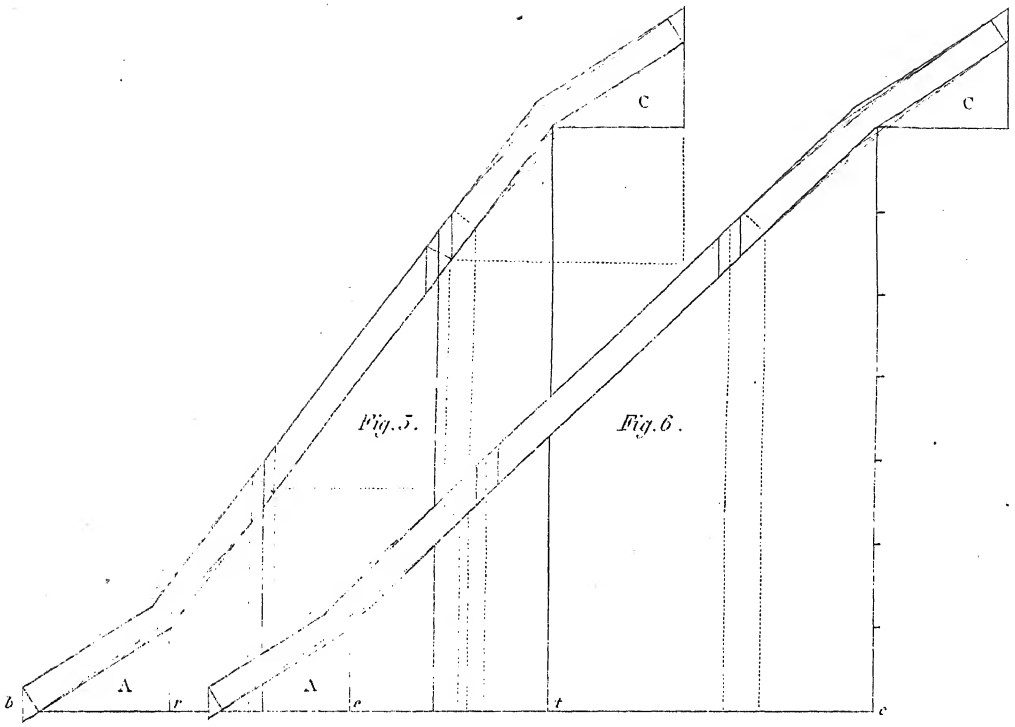

Fig. 5.

Fig. 6.

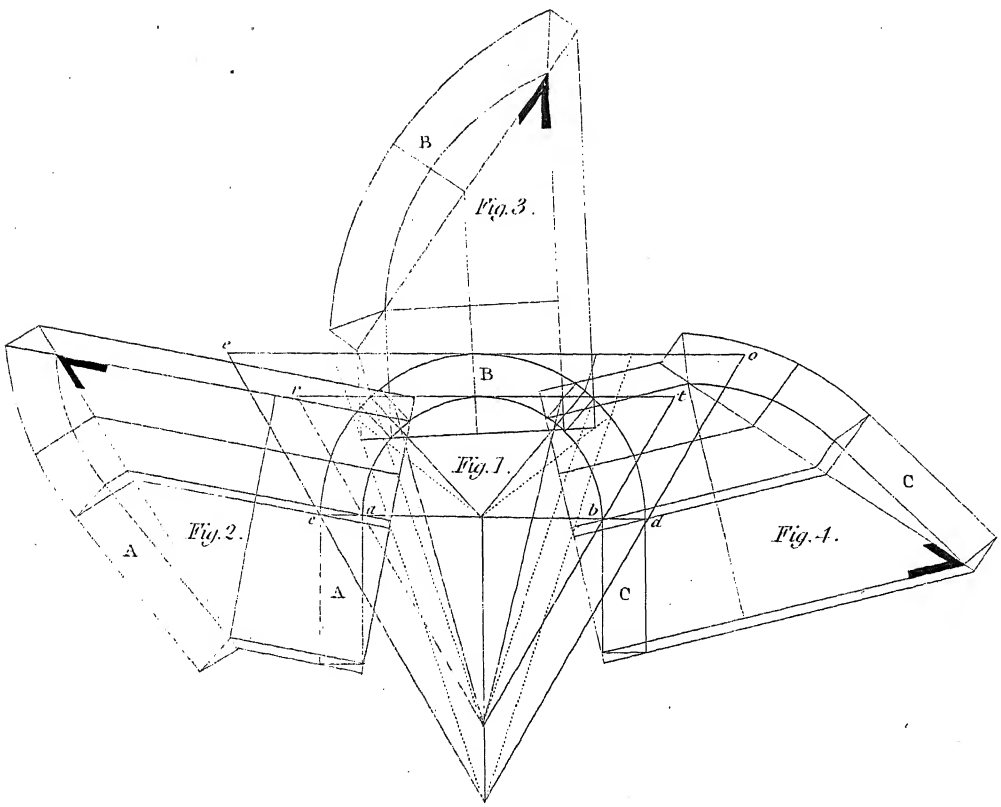

Fig. 3.

Fig. 1.

Fig. 2.

Fig. 4.

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PLATE 11.

Exhibits the plan of forming the face and falling moulds for the rail of a semi-circular stairs with six winders, having fliers attached above and below.

A, *B*, *C*, fig. 1, being the given plan of the rail.

The lengths of the concave and convex semi-circumference of the given plan are obtained in the same manner as in the preceding Plates. *a b* being the diameter of the concave, and *c d* of the convex, *r t* and *e o* will be their stretch-outs. The stretch-out *r t* of the concave being applied upon the base from *r t*, fig. 5, also *e o* being applied upon the base from *e* to *o*, fig. 6; then at the points *t* and *o* erect the height-rods, and at their upper extremities place the pitch-boards *C C*, the base of which is equal to the straight part *C* of the given plan, fig. 1. The pitch-board, *A A*, figs. 5 and 6, being placed at *r* and *e* upon the base; the distances upon the base of the pitch-board *A* of the concave falling moulds from *r* to *b* is equal to the straight part *A* of the given plan, fig. 1. The upper easing of the concave falling mould is formed the same as the lower, except its being reversed. Obtain the points from the easings of the concave mould, fig. 5, and apply them to the concave stretch-out of the given plan, fig. 1; then by the dotted lines obtain the difference of the concave and convex easings, and apply it to the concave mould, fig. 6; then form the easings.

The manner of forming the butt-joints upon the concave falling mould, fig. 5, and their application to the given plan, fig. 1, from thence the formation of the face moulds, *A*, *B* and *C*, of figs. 2, 3 and 4, from the parts *A*, *B* and *C* of the given plan, fig. 1, are the same as in the preceding Plates.

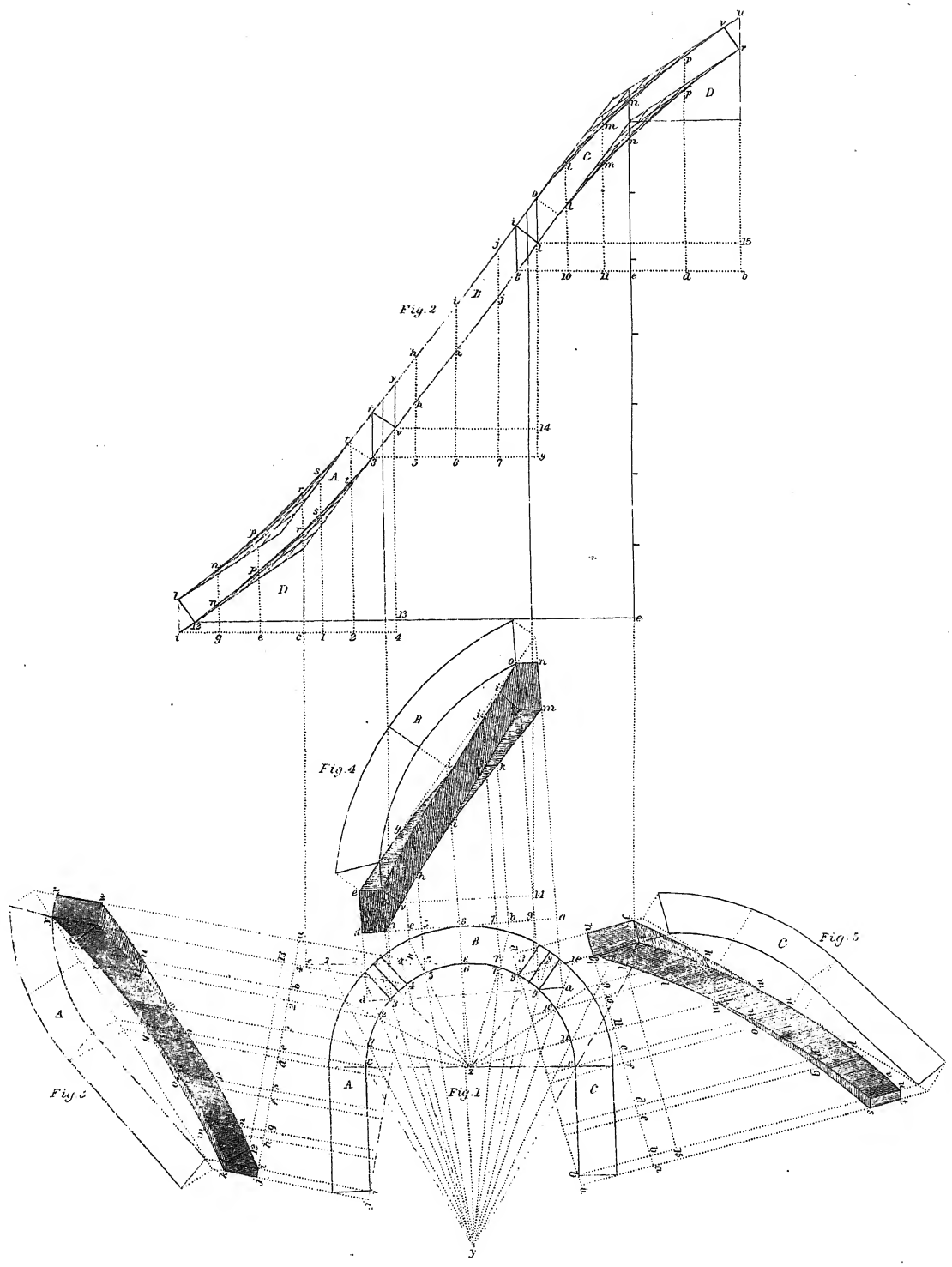

Fig. 2

Fig. 4

Fig. 5

Fig. 3

Fig. 1

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PLATE 12.

Shows the manner of obtaining the required thickness of stuff, and proper twist of the rail-pieces, also the face moulds for each respective rail-piece.

To obtain the corresponding points from the parts *A B* and *C*, fig. 2, through the given plan, fig. 1, to the parts of figs. 3, 4 and 5. Draw the concave stretch-out, *c e*, of fig. 1 (it should be observed that the given plan, figs. 1 and 2, is the same as figs. 1 and 5 of Plate 11, also the location of the joints). Erect the perpendiculars from *c e*, the stretch-out, to *c e*, the base of fig. 2. Draw the dotted line *i*, 4, parallel to the part of the base 1 2, 1 3, of the part *A;* then divide the distance *i* 4 into any number of parts, as *g*, *e*, *c*, 1 2. Erect perpendiculars from each of those points to *n*, *p*, *r*, *s*, *t*, and *y*, or upper edge of said mould; then draw the chord-line *j h*, touching the concave points, *i*, 4, of the part *A*, of the given plan, fig. 1, and erect perpendiculars from the points *j*, *i*, and 4, *h;* then draw *a j* parallel to the chord *j h;* then take the several distances, *i g*, *g e*, and *e c*, upon the base, *i* 4, fig. 2, and apply them upon the parallel to the chord, fig. 1, from *i* to *g*, *g* to *e*, and *e* to *c;* then take the distance *i j*, and apply said distance from *g* to *h*, *e* to *f*, and *c* to *d;* then erect the several perpendiculars from the chord-line, cutting the points *h g f e* and *d c*, upon the parallel to the chord; then take the distance from *c* to 1, 1 to 2, and 2 to 4, and apply said distances upon the stretch-out of fig. 1, from *c* to 1, 1 to 2, and 2 to 4; then draw the lines 1, *y*, 2, *y*, and 4, *y*, and at the point of intersection of said lines to the concave side of the given plan, draw lines from the centre *z* through said points of intersection to the convex side of the given plan; then erect perpendiculars from the chord and convex side of the given plan, cutting the points 1 2 and *b* upon the

parallel to the chord; then obtain the several heights from the part *A*, fig. 2, from the base *i* 4 to *l*, *n n*, *p p*, *r r*, *s s*, *t t*, and *v y*, and apply said distances upon the perpendiculars from the parallel *i l*, *g n n*, *e p p*, *c r r*, 1 *s s*, 2 *t t*, and 4 *v y*, for the concave side; then draw *l k*, *n m*, *p o*, *r q*, *t u*, *v w*, and *y x*, parallel to *j a*, and *j k*, *h m*, *f o*, *d q*, *b u*, and *a w x*, for the convex side; then trace out the form of the rail-piece through the given points *i*, *n*, *p*, *r*, *s*, *t*, *v*, for the lower, and *l*, *n*, *p*, *r*, *s*, *t*, *y*, for the upper edges of the concave side, and *j*, *s*, *u*, *w*, for the lower, and *k*, *m*, *o*, *q*, *s*, *x*, for the upper edges of the convex side; then draw the dotted line 12, 13, which being the base line of the joint, and 13, *v*, the height, from 12, 13, as 13, *v*, fig. 2, also the location of the joints, 12, *l*, and *v*, *f*, being the same, which completes the form of said rail. The face-mould, *A*, is obtained in the same manner as has been described in the preceding Plates. The parts *B* and *C*, of figs. 4 and 5, are obtained from the parts *B* and *C*, fig. 2 (as will be seen by tracing the corresponding points), through the parts *A* and *C* of the given plan, fig. 1, in the same manner as was the part *A*, fig. 3, from the part *A*, fig. 2, through the part *A* of the given plan, fig. 1.

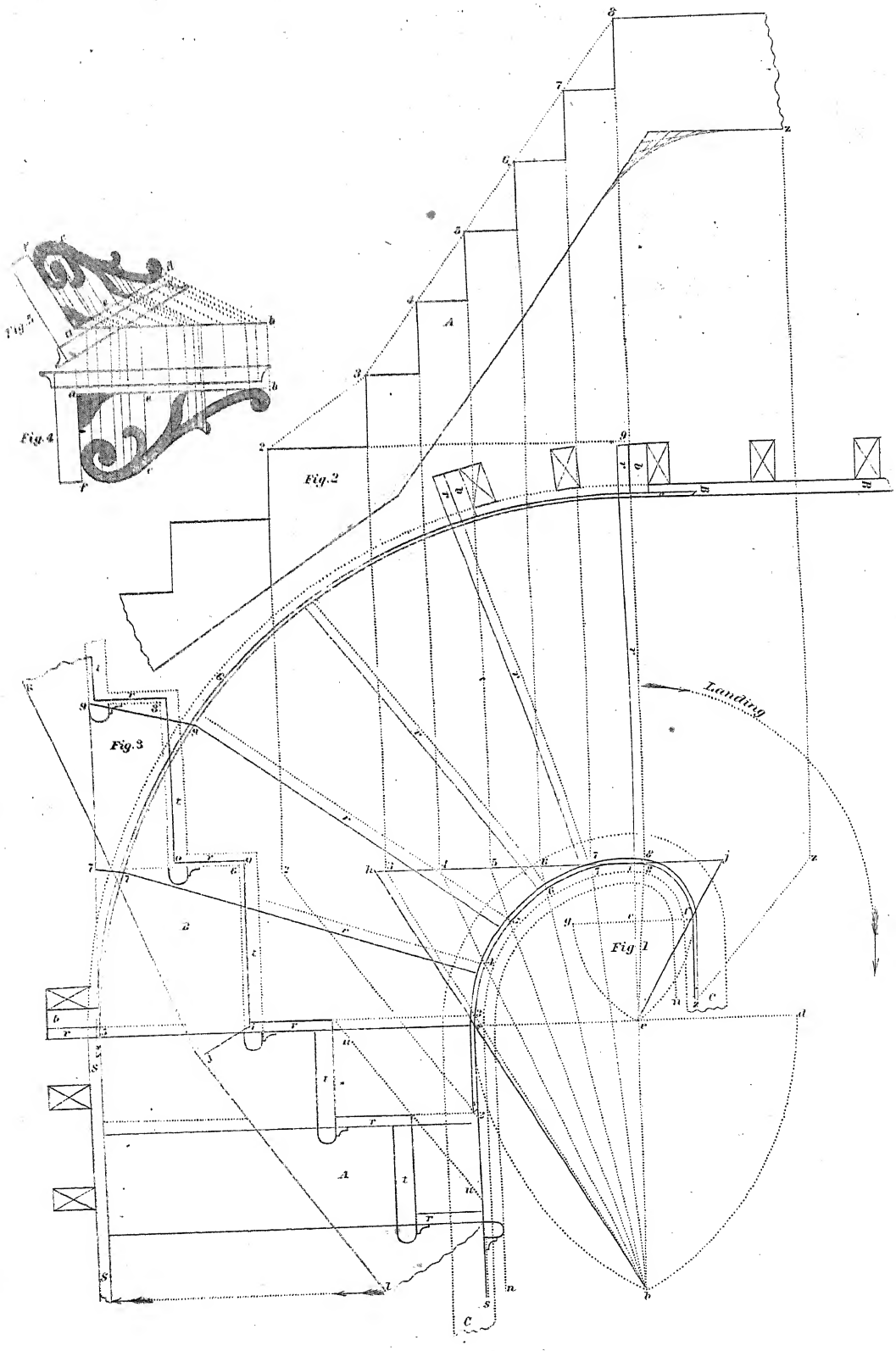

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PLATE 13.

Fig. 1 shows the plan of a stairs having five winders, the well-hole being formed by two quadrantal parts, a larger and smaller one, which may be termed a quarter space.

Fig. 2 shows the plan and elevation of the veneer for the concave side of the stair.

Fig. 3 shows the plan and elevation of the veneer, or skirting for the convex side of the stair.

Fig. 4 shows the plan of a bracket.

Fig. 5 shows the manner of diminishing the size of the given bracket, fig. 4.

Fig. 1. Having *c a* and *c i* as radius, describe the quadrantal part, *a i*, of the larger, and having *e i* and *e f* as radius, describe the quadrantal part, *i f*, of the smaller. To obtain their stretch-out, *h j*, let *a d* be equal to twice the given radius, *c a;* then having *a d* as centres, describe the arcs *d b* and *a b*, also let *f g* be equal to twice the given radius *e f;* then having *f g* as centres, describe the arcs *g c* and *f c*, draw the tangent line *h j;* then draw *b* through *a* to *h*, and *c* through *f* to *j;* then *h j* will be the length of the concave semi-circumference from *a* to *f*, or face of *v v*, the veneer, which commence at 2, and end at *z*.

S, The face side of the front string, the dotted line at *s* showing the face of the bracket, *n n*, the line of nosing.

C, *C*, the given plan of the rail.

r r r r, the risers.

b b b, the plank risers secured to the studs. The student will observe that the carriage is framed in the same manner as fig. 1, Plate 9.

S S, the wall-string, or skirting, having the lower end of the veneer attached.

G, the ground for the reception of *v v*, the veneer.

B B, the base upon the landing, having the upper end of the veneer attached.

Fig. 2, *A*, the veneer being formed in the same manner as fig. 2, Plate 9.

Fig. 3, *A*, the part of the wall-string or skirting, *l j* the upper edge, and *u u* the lower; *r r r* the risers, and *t t* the treads. To obtain the length of the part *B* of the veneer for the convex side, proceed in the same manner as the concave; then 5 7 9 will be the stretch-out of 5 7 9, or convex end of the first and second winder; the line *k j* is the upper edge, and *j i* shows the junction of the part *B* of the veneer to the part *A*, and *i g o* the lower edge of the veneer or skirting, which being inserted into the tread and riser by a groove being cut to the depth of half an inch, the width being cut sufficient for the reception of the veneer or skirting, the thickness of the veneer should be governed by the size of the circle, not more than ½ inch, nor less than ¼ inch. The places should not be cut out for the reception of the tread and riser in the concave veneer until put to its proper place and secured. Fig. 4 being the given plan of the bracket, *f a* the height, and *a b* the length; draw *a b*, fig. 5, parallel to *b*, fig. 4; then draw the several ordinates perpendicular from the base of the given bracket, fig. 4, to *a b*, fig. 5; then from the point *a*, fig. 5, draw the diminishing line *a d* at any given angle; then continue the ordinates from *a b* to the diminishing line, *a d*; then erect them perpendicular to *a d*, and obtain the several distances from the several ordinates of fig. 4, as *a f*, *e c*, &c., and apply said distances upon the several ordinates from *a d*, fig. 5, as *a f*, *e c*, &c. Then trace out the form of the bracket. By this method the bracket may be enlarged as well as diminished.

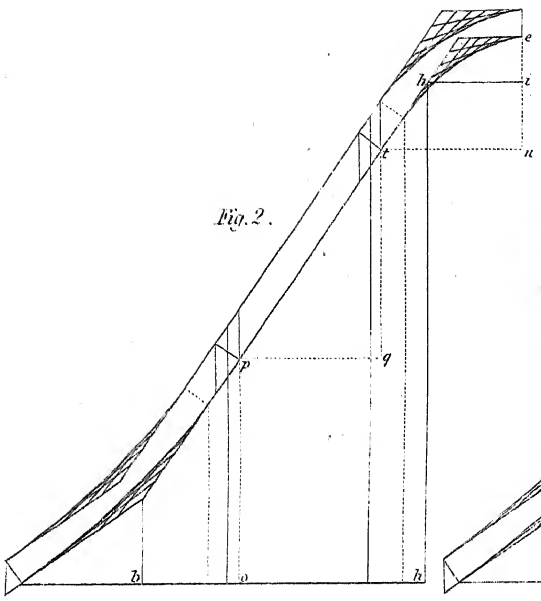


Fig. 2.

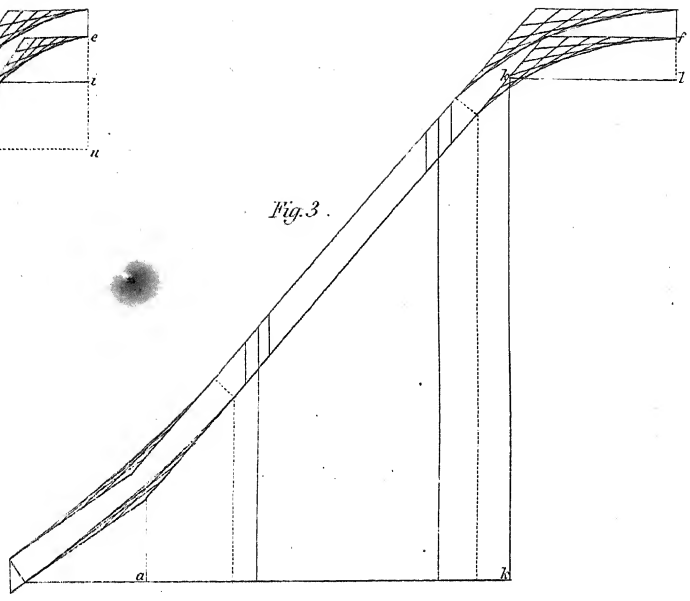


Fig. 3.

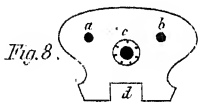


Fig. 8.

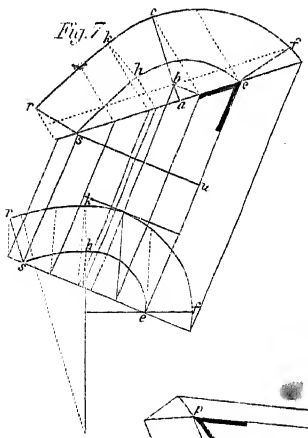


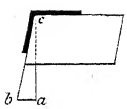
Fig. 7.

Fig. 5.

Fig. 6.

Fig. 1.

Fig. 4.



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R. Miller, Printer

PLATE 14.

Being the plan of the rail for Plate 13.

Fig. 1, the given plan of the rail.

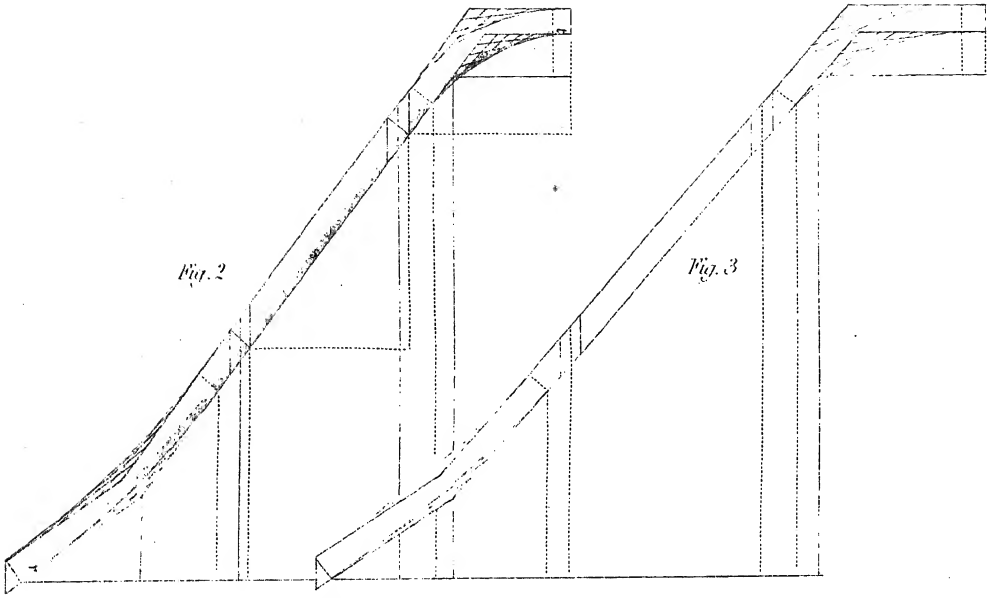
Figs. 2 and 3, the concave and convex falling moulds.

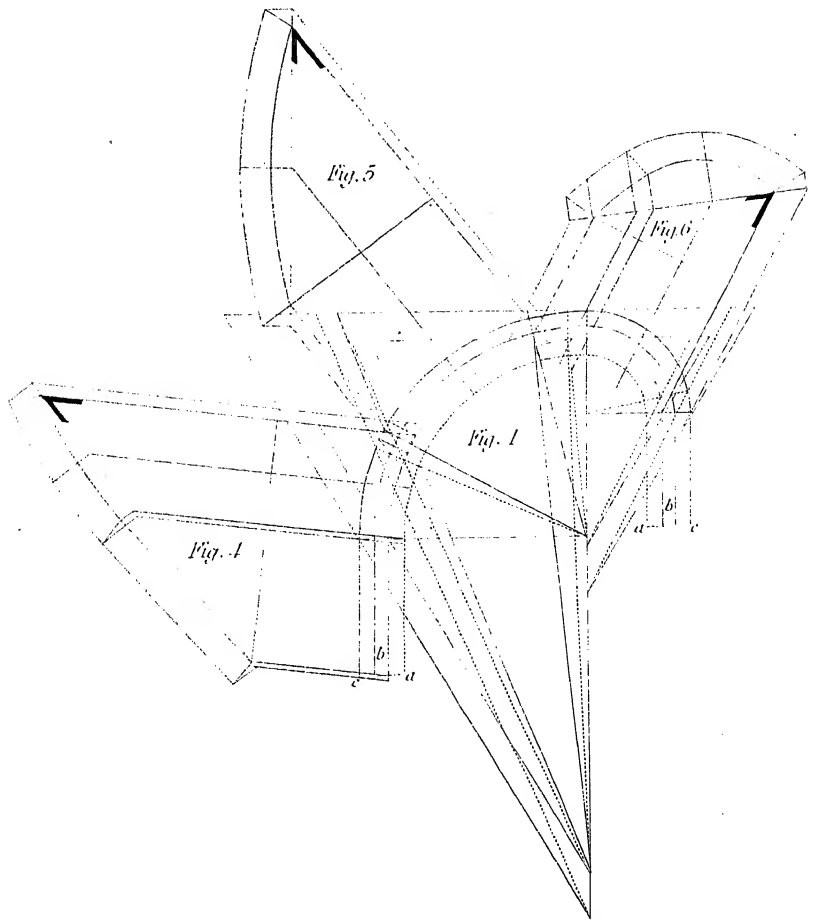
Figs. 4, 5 and 6, the face moulds for each respective part of the given plan, fig. 1, being formed in solid section.

Fig. 7, being the same as fig. 6, the face mould being formed for the spring of the plank.

The manner of obtaining the stretch-out of the given plan, fig. 1, is the same as has been described in fig. 1, Plate 13, and its different points, for the formation of the falling moulds, and easings, and their application to the given plan, fig. 1, for the formation of the face moulds, are the same as has been described in the preceding plates; by tracing the letters, the reader will at once perceive the corresponding points.

Fig. 8 shows the plan of a rail-piece at the joint, *a b*, the dowel or iron pins, made of thick wire to keep the rail-pieces from turning; *c*, the hand rail screw; *d*, shows the form of the groove for the reception of an iron core. The groove should be formed before working the moulding upon the rail.





W.Kemble, sc N.Y.

PLATE 15.

Shows a method by which the smith may be confined to the position of the rail, so as to give the proper twist to the iron core, and obtain its neat length.

First draw the ground plan of the rail or form of the well-hole, as, *a a*, fig. 1 of the concave and *c c* of the convex sides of the given plan; then obtain the size intended for the core, and apply it to the centre of the ground plan as is shown at the shaded part, *b b*, then obtain the stretch-outs of the concave side of the shaded part *b b*, and the convex side, *a a*, of the given plan, the formation of the falling moulds, figs. 2 and 3, and their easings, and manner of obtaining the joint and their application to the given plan, fig. 1, for the formation of the face moulds, figs. 4, 5 and 6, is the same as has been repeatedly described. The shaded part, *r s t*, of the concave falling, fig. 2, shows the depth of the groove for the reception of the core. The chord lines, of each respective part of the face moulds, figs. 4, 5 and 6, are drawn to the concave side of the shaded part, *b b*, which gives the proper width to the face moulds. Then by applying the face and falling moulds to the plank which is of hard wood. The wreath pieces being worked to the lines of the moulds and joints cut and screwed together, then set a gauge to the width of the groove or shaded part, *b b*, or width of the core, fig. 1, and apply it to the lower side of the wreath from the concave edge, then set the gauge to the depth of the groove for the core or shaded part, *r s t*, fig. 2, and apply it to the lower edge of the concave side of the wreath;

then cutting the groove to the gauge mark (which may be performed more readily by a tool usually termed a router), the wreath will be complete and ready for the smith to form the core to the twist of the wreath part of the rail, which should be done with great exactness, that the workman may have no fitting to do when placing the rail or cap upon the core. The student will observe that Plate 14 is the plan of the rail for Plates 13 and 15; Plate 15 is drawn for the formation of the rail for the use of the smith.

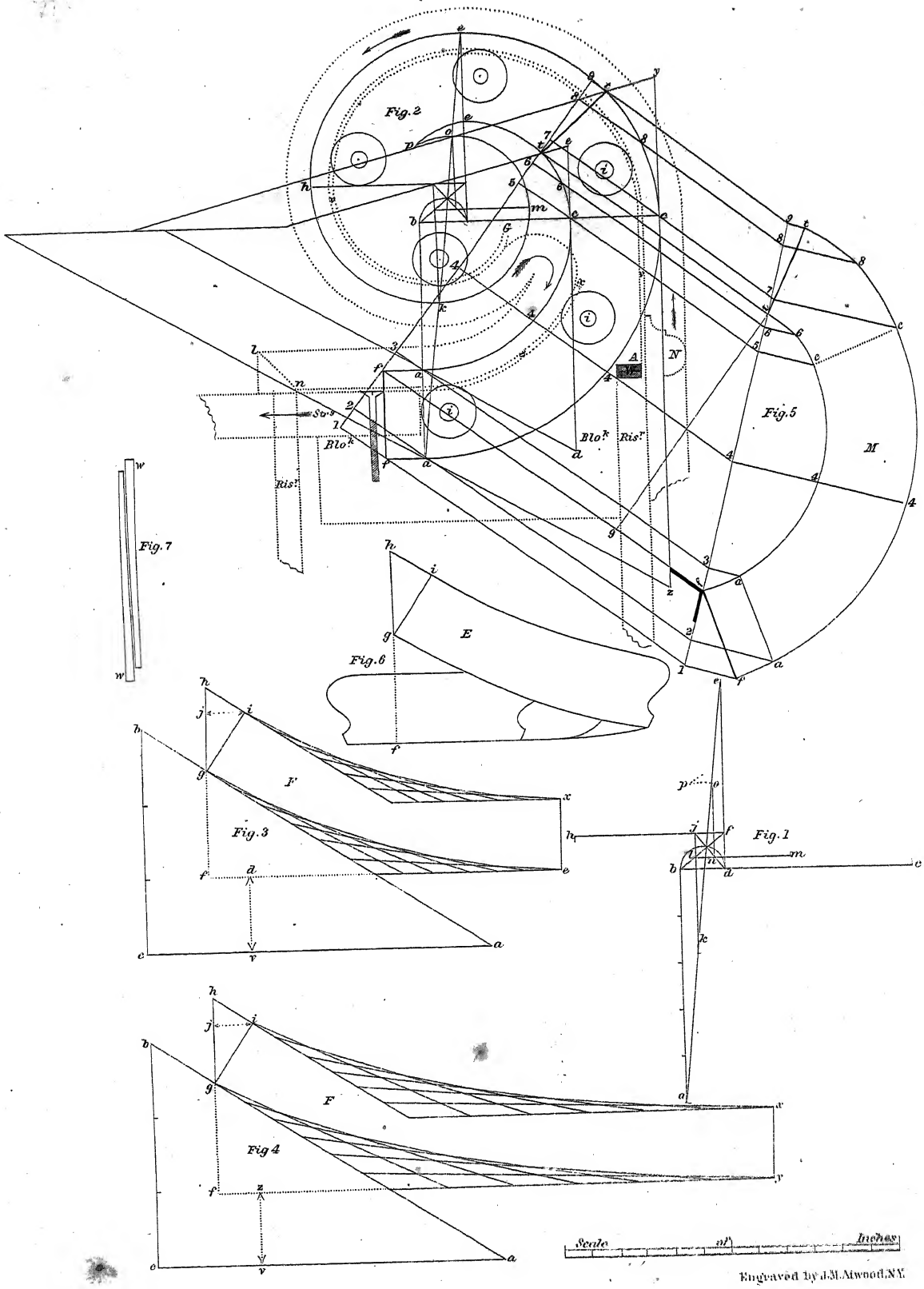


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PLATE 16.

To draw the scroll for a hand-rail, and curtail step for the same.

Fig. 1 shows the manner of obtaining the centres for the formation of the scroll and curtail step. It should be observed that the width of the scroll is governed by the width of the rail, which is one-fifth of the extreme width of the scroll. The width of the scroll being obtained, divide it into nine equal parts. Then draw the line *a b*, equal to five of the nine parts, and draw *b c* at right angles, and equal in length to *a b*, then *a c* will form the first quadrant. Take the distance equal to one of the nine parts, and apply it from *b* to *d*. Draw *d e* at right angles to *d c*, then *c e* will form the second quadrant; then *a e* will be the required width of the scroll. Describe the semicircle *b d*, and draw the diagonal line from *a* to *e*, and at the point where the diagonal passes through the semicircle *b d*, draw the line from *b* through the said point to *f*, and draw *f h* at right angles to *f e;* then *e h* will form the third quadrant. Draw *d j* through the point of intersection of *b f* to the semicircle, and draw *j k* at right angles to *j h;* then *h k* will form the fourth quadrant. At the point of intersection of *j k* to *b f* draw *l m* at right angles to *l k*, then *k m* will form the fifth quadrant. At the point of intersection of *l m* to *j d*, draw *n o* at right angles to *n m;* then *m o* will form the sixth quadrant. In describing the quadrant *n m*, the segment of the circle should terminate at *p*.

Fig. 2. *Shows the manner of drawing the scroll and curtail step.*

The centres of the several quadrants having been obtained in the manner just described, and their radii being given, commence at *a*, and describe the several

quadrants *a c*, *c e*, *e h*, *h k*, *k m*, and *m o*, which continue to *p*, which completes the convex side of the scroll. Then set off the width of the rail, from the convex side at *a* to *a*, of the same radius, and from the centres of the first and second quadrants describe the arcs from *a* through the radius *c* and *e* to *p*, which completes the concave side of the scroll. Then apply the portion, *f a*, of straight rail, to the first quadrant. (It is always necessary to have a small portion of straight rail attached to the given plan of the scroll, and it should not be less in length than the required overwood for obtaining the butt joint. If not attached, it will shorten the upper side of the twisted part of the scroll equal to the required overwood, and form an angle at the joint, when connected to the straight rail.) Then square across the rail at *t t*, and obtain the stretch-outs of the arcs, *a c t*, of the convex, also *a c t*, of the concave sides of the given part of the scroll, which stretch-outs are obtained in the same manner as the stretch-outs in the preceding plates; then *d e* will be the stretch-out of the concave *a c t*, and *z y*, the stretch-out of *a c t*, of the convex sides of the given part of the scroll.

To obtain the concave falling mould at F, fig. 3, *from the part of the given plan, fig.* 2.

Let *a b c* be the pitch-board, and divide *c b*, the riser, into three equal parts; then at the first part from *c* draw *e f*, parallel to *a c*. Then obtain the length of the radius from the centre *b* to the convex *c*, fig. 2, of the first quadrant, and apply it upon the base line of the pitch-board, from *a* to *v*. Then obtain the point *d* upon the base of the falling mould, which is perpendicular to *v*, then take the concave stretch-out, *d e*, fig. 2, and apply it upon the base of said mould, from *d* to *e;* then from *e* set up the width of the mould to *x;* then apply the portion *a f*, of straight rail, fig. 2, from *d* to *f*, fig. 3, and erect the perpendicular *f h*, and draw *h x* parallel to *g e*, then square across the mould at *g i* and *e x;* then *e x* and *g i* will be the required joints, and *j i* the required overwood for *g i*. Then form the easing, and the concave falling mould will be complete.

The convex falling mould, *F*, fig. 4, is formed in the same manner from the convex points, fig. 3, as was the concave mould, fig. 3, from the concave points, fig. 2.

To draw the face-mould M, fig. 5, from the part of the given plan, fig. 2.

First draw the chord line, 1 9, touching the concave points, *f t*, then from the chord line erect the several perpendiculars from the points 1, 2, *f*, 3, 4, 5, 6, *t*, 7, 8 and 9. Then draw *g t* parallel to the chord line, 1 9; then obtain the height from *f g*, fig. 3, or fig. 4, which is the same, and apply it to *g f*, fig. 5. Then draw the hypothenuse, 1 9, touching the point *f*, also the parallel at *t*, and draw lines at right angles to the hypothenuse from the points 1, 2, 3, 4, 5, 6, 7, 8 and 9; then obtain the several distances, as 1 *f*, 2 *a*, 3 *a*, 4 4 4, 5 *c*, 6 6, 7 *c*, 8 8, and 9 *t*, from the chord line, fig. 2, and apply them upon the perpendiculars to the hypothenuse, fig. 5, from the points 1, 2, 3, 4, 5, 6, 7, 8 and 9, to *f a a*, 4 4 *c*, 6 *c*, 8 and *t;* then draw the line *t t*, which will be the end of the required mould. The points *t* 6 *c*, and *t* 8 *c*, of the segment, also *c* 4 *a* of the concave, and *c* 4 *a* of the convex being obtained, describe the arcs through said points; then *a f* and *a f* is the straight part, and *f f*, the end of the required mould.

The manner of applying the face-mould to the plank, also the application of the falling moulds to the rail-piece, and the cutting away of the superfluous wood, is the same as has been described in the preceding plates.

At *E*, fig. 6 shows the elevation of the scroll when completed, and *f g*, the height equal to *f g*, of the falling moulds, and *g i* the joint.

To draw the curtail step and block for the same, as is shown by the dotted lines at fig. 2.

First obtain the size of the baluster *i* at its base, the centre of which being the centre of the rail; then draw the lines *b*, of the bracket, from *n* to *x*, the face of which touching the base of the baluster, also being the required length of the bracket, the circular part *a x*, being drawn from the centre *b* of the first quadrant, which produces the concave side of the *Block*. Then cut a gain in the *Block* for the reception of the *String*, which is glued and screwed to the *Block;* the concave side of the *Block* is made sufficiently smooth from the junction of the *String* to the *Block*, to *x*, that it may not require any veneer; *Risr*, the second riser. For the veneer and

convex side of the block, set back from the convex edge of the rail, at the radius *c*, the distance equal that the bracket *b* is from the concave, which will be the face of the lower riser, and from the centres of the rail trace out the lines *v*, of the veneer (the face of which touching the base of the baluster, the inner line of the veneer being the convex side of the *Block*), around to *G*, where the end of the veneer is let into the *Block*, a groove being made by the cut of a fine saw for its reception. It will be observed that *v* the veneer and *Riser* are the same piece, there being a gain cut into the *Block* at *A*, for the reception of the *Riser* part. To obtain the length of *v* the veneer, take a small cord, and by applying the end to the depth of the groove at *G*, then encircle the *Block* with it around to *A*, which will be the length required for the veneer part, at the same time allowing for *W*, the wedges (which are formed as *w w* at fig. 7), to strain the veneer close and smooth to the *Block*. The form of the *Block* being worked out to the given lines, and gains cut for the reception of the *String* and *Riser*. Then prepare a sizing of glue and size the *Block* upon the convex side, from *G* around to *A*, also the gains, and let it become dry before the veneer is applied. The plank from which the *Block* is formed should be perfectly seasoned.

To prepare the veneer and riser.

The length of the riser being obtained, including the length of the veneer, and got to its proper width and thickness, then gauge the part for the veneer about one-eighth of an inch in thickness, and with a rip-saw slit out the veneer. In planing up *v*, the veneer, give it a gradual diminish from the *Riser* to the end, that it may enter the groove at *G*. Then put the veneer part into hot water, and let it remain until it becomes soft and easily bent, being then ready for application to the *Block;* give the *Block* another good coat of well prepared glue from *G* around to *A*, also the gain for the reception of the *Riser*. Then place the end of the veneer square into the groove at *G*, and carefully bend it around the *Block*, until it will admit the *Riser* into the gain at *A*. The wedges being driven properly, one from each side of the *Block*, will strain the veneer smooth and close to the *Block*.

It may be necessary to place a smooth piece of board upon the face of the veneer, from the *Riser* or wedges at *A*, to the radius *c* of the first quadrant, that the veneer may adhere to the *Block;* then taking a hand-screw and placing it across the *Block* at *x v*, to press the board against the veneer, and letting it remain until it becomes perfectly dry.

To draw the curtail step.

The diagram at *N*, fig. 2, shows the projection of the nosing, and the outer dotted line its continuation around the convex side to the concave, to *l n*, at the second riser, where the return of the nosing is round the end of the bracket, which gives the form and size of the curtail step.

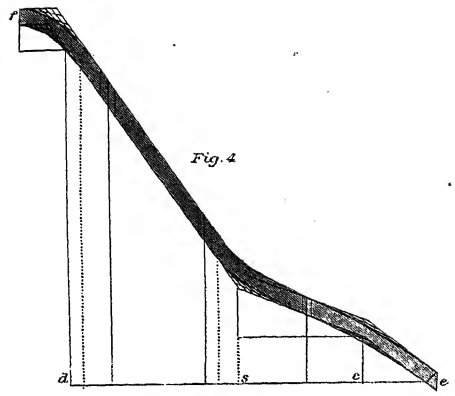

Fig. 4

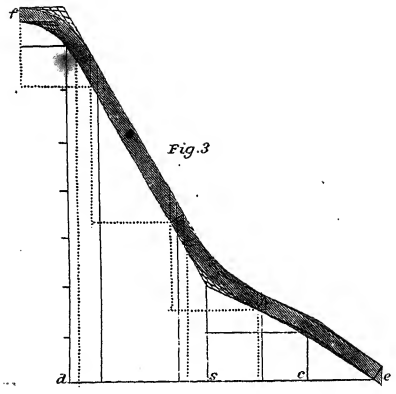

Fig. 3

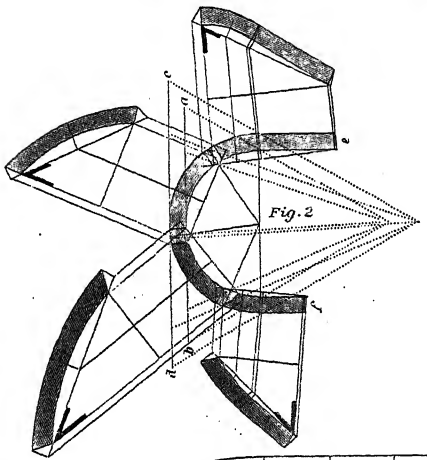

Fig. 2

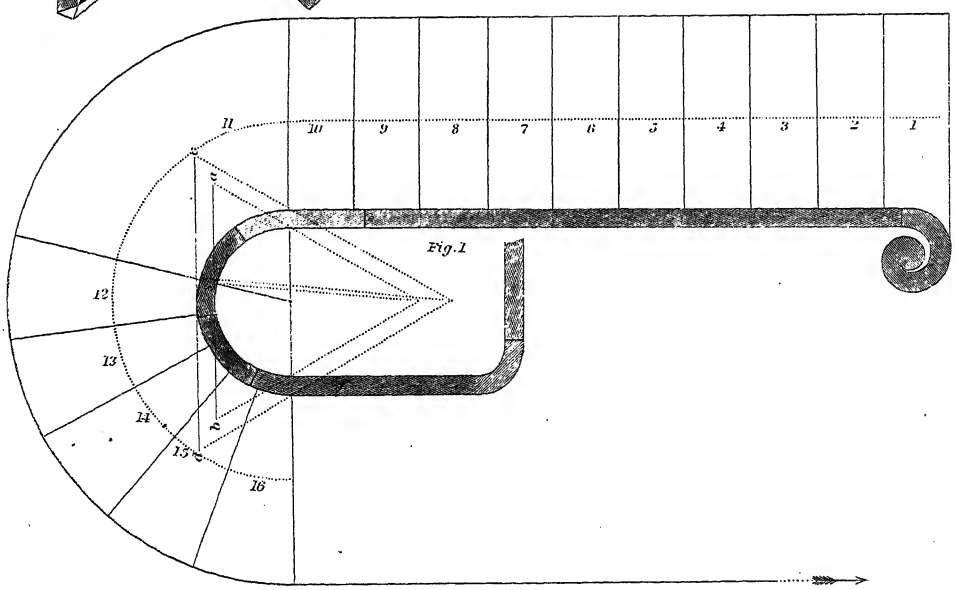

Fig. 1

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PLATE 17.

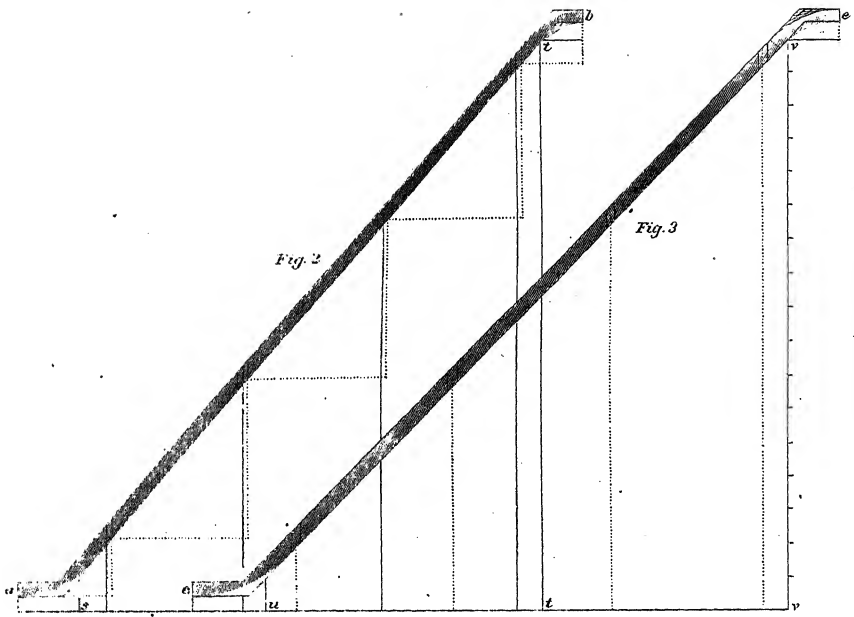
Exhibits the ground plan of a stair, and rail with scroll and curtail step having ten fliers resting against the landing, and five winders in the semicircular part.

Fig. 1, being the given plan of the stairs and rail.

Fig. 2, the plan of the rail and face-moulds for the same.

Figs. 3 and 4, the concave and convex falling moulds.

The manner in which the different points are obtained, is the same as has been repeatedly described, which will be seen by the corresponding letters.



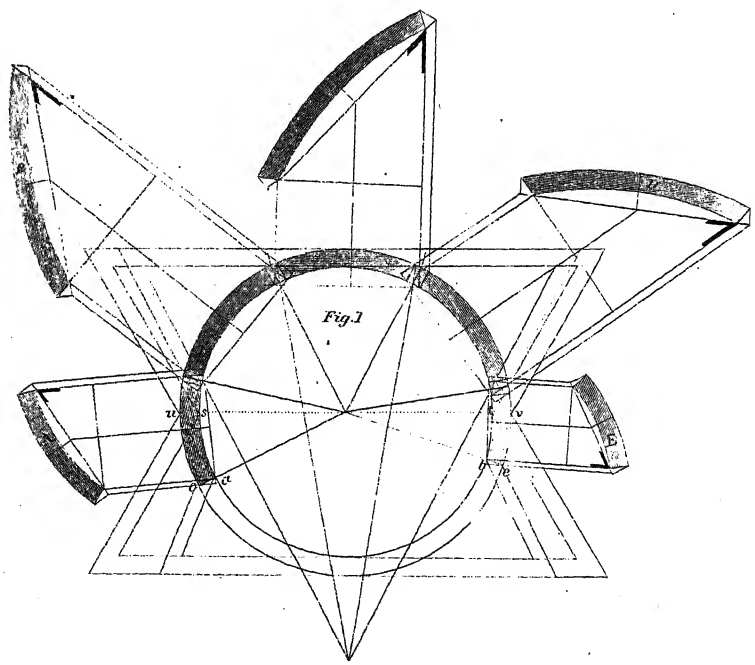


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PLATE 18.

Shows the manner of forming the moulds, for the rail of a circular stairs, having sixteen winders, running from a landing to a rake, and rake to a landing.

Fig. 1 being the given plan of the rail, the winders commencing at *s u* and ending at *t v* and from *t v* to *s u* the landing from *a* to *b* and *c* to *d* of figs. 2 and 3 being the length of the concave and convex falling moulds, when placed upon the height rods *t t* and *v v*. The stretch-outs of *s t* and *u v*, and their application to the base of figs. 2 and 3 for the formation of the concave and convex falling moulds, and obtaining the joints and their application to the given plan, fig. 1, the heights being obtained in the same manner from the several joints of fig. 2 for the formation of the face-moulds *A B E D* and *E*, as has been described in the preceding plates. It should be observed that the lower easing at *a*, fig. 2, is raised half a riser above its base that the balusters on the landing may be equal in length to the long balusters on the rake. The perpendicular at *s* being the first riser and *t t* the height rod, which gives the proper angle of inclination to the falling moulds, and the same to the concave side of the rail. The distance from *a* to the hypothenuse (the lower edge of said mould) is twelve inches, and that upon the rake eight inches, then divide the distance into six equal parts, and by the intersection of lines from each of those parts the easing will be formed. The upper easing is the same as has been described in the preceding plates, also the manner of obtaining points for the easing upon the convex falling mould.

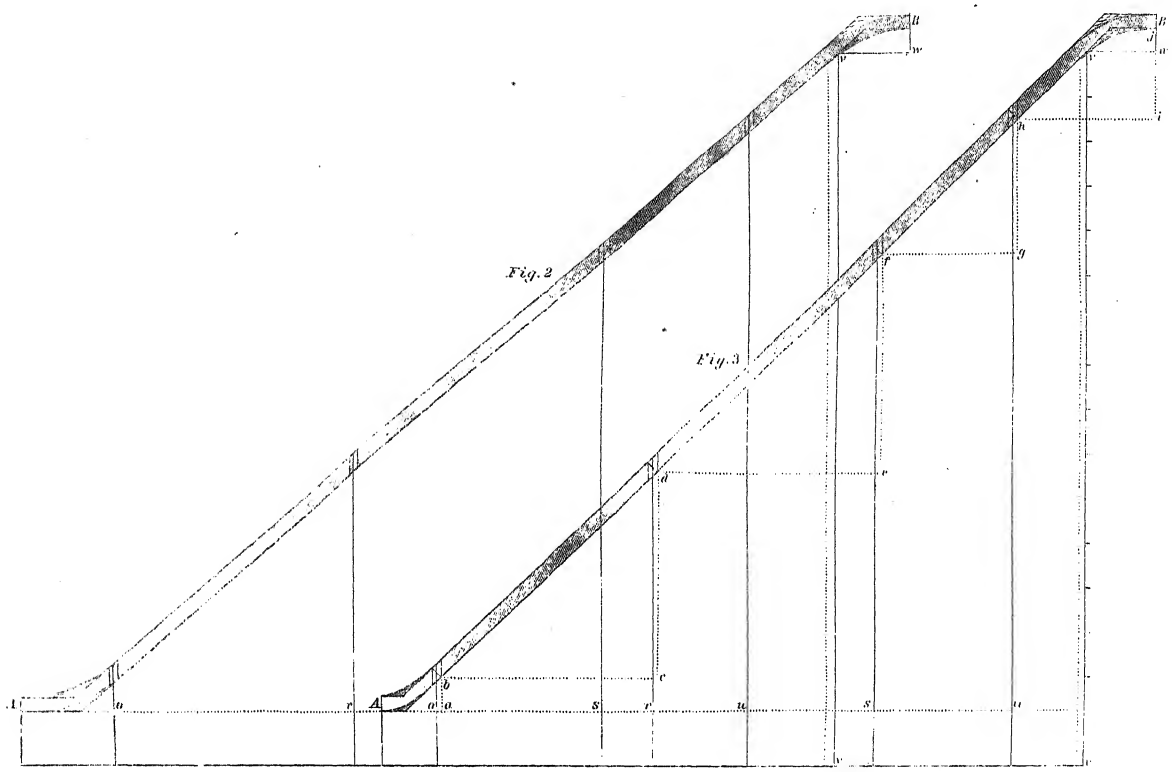


Fig. 2

Fig. 3

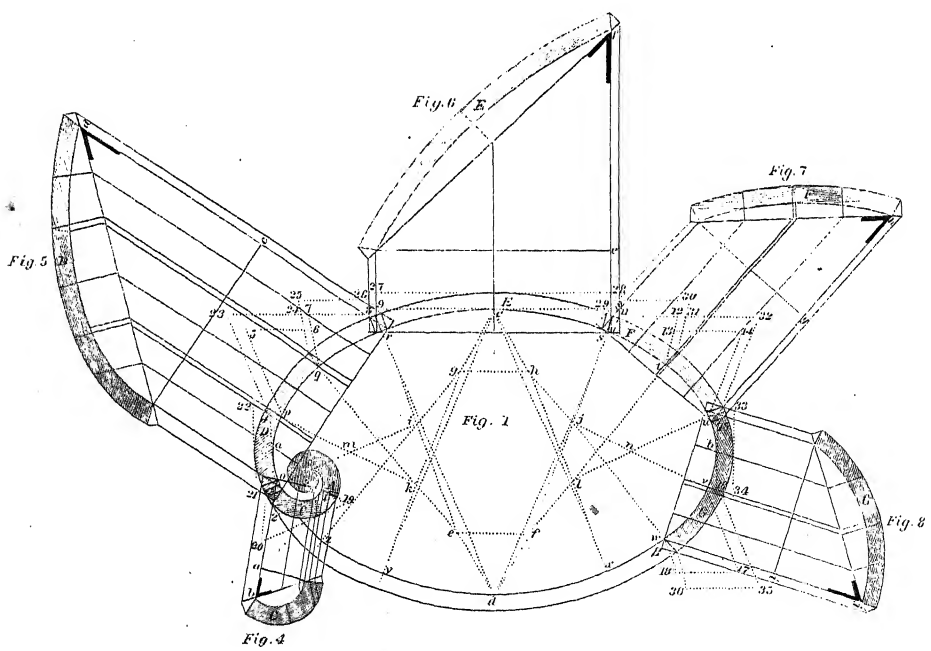


Fig. 6

Fig. 7

Fig. 5

Fig. 1

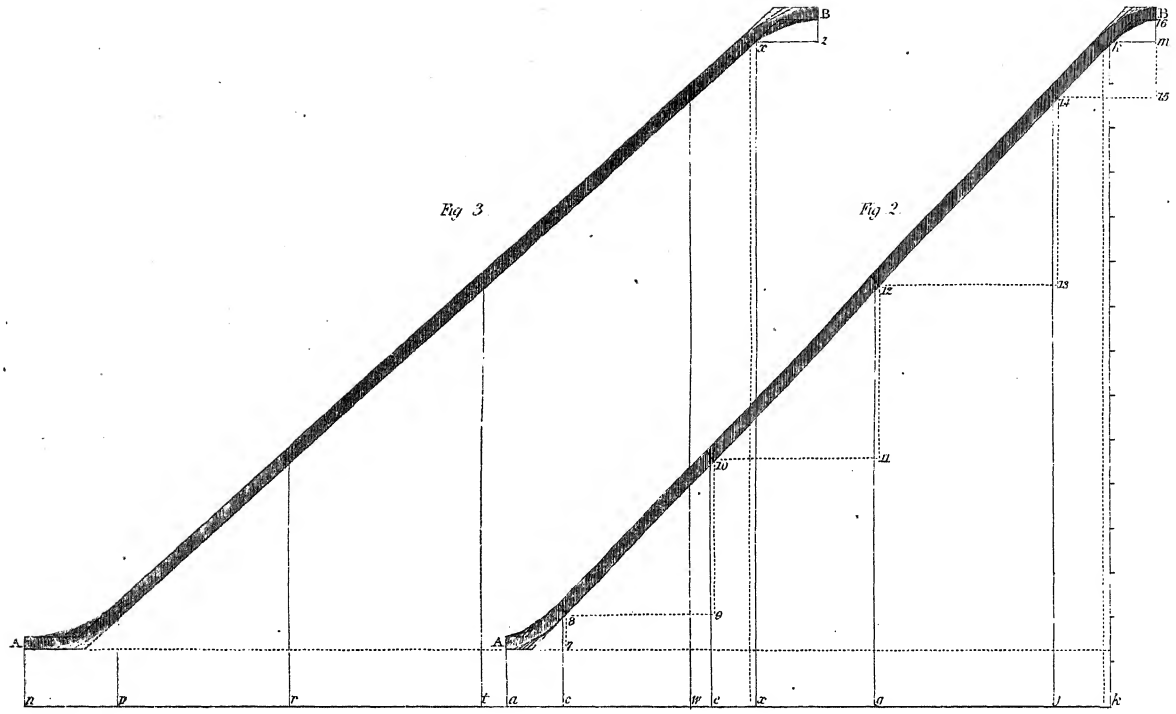
Fig. 8

Fig. 4

PLATE 19.

Exhibits the plan of the rail and scroll for a stairs, the well-hole being elliptical.

Fig. 1 being the given plan of the rail, whose centres *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *l*, *m* and *n*, being obtained as fig. 19, Plate 22, for the formation of an ellipsis by which the concave and convex sides of the given plan, fig. 1, are formed, the stretch-outs 1 2 (of the scroll), 3 4, 5 6, 7 8, 9 10, 11 12, 13 14, 15 16, 17 18, of the concave sides, and 19 20 (of the scroll), 21 22, 23 24, 25 26, 27 28, 29 30, 31 32, 33 34, 35 36, of the convex sides of the several segments, *o p*, *p q*, *q r*, *r s*, *s t*, *t u*, *u v*, *v w*, of the several quadrants, being obtained for the formation of the concave and convex falling moulds, figs. 2 and 3, which being raised to the height of 1 ⅛ of a riser above its base, also the location of each respective joint and formation of the easings upon the same, and its application to the given plan, fig. 1, for the formation of the face moulds, figs. 4, 5, 6, 7 and 8, are the same as has been described in the preceding plates. It should be observed that the stretch-out must be obtained from the concave and convex sides of the given plan of the rail, let the well-hole be whatever form it may, before the concave and convex falling moulds can be formed. The carriage for an elliptical stair may be framed in the same manner as Plate 9.



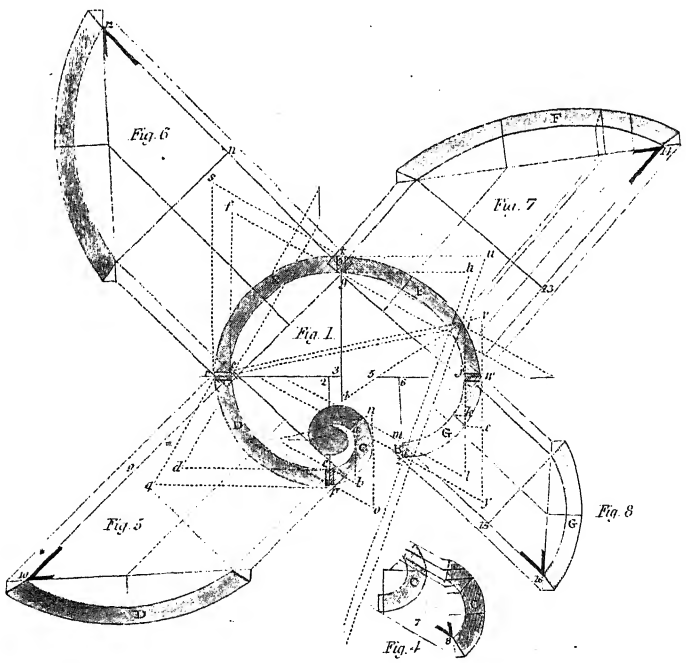


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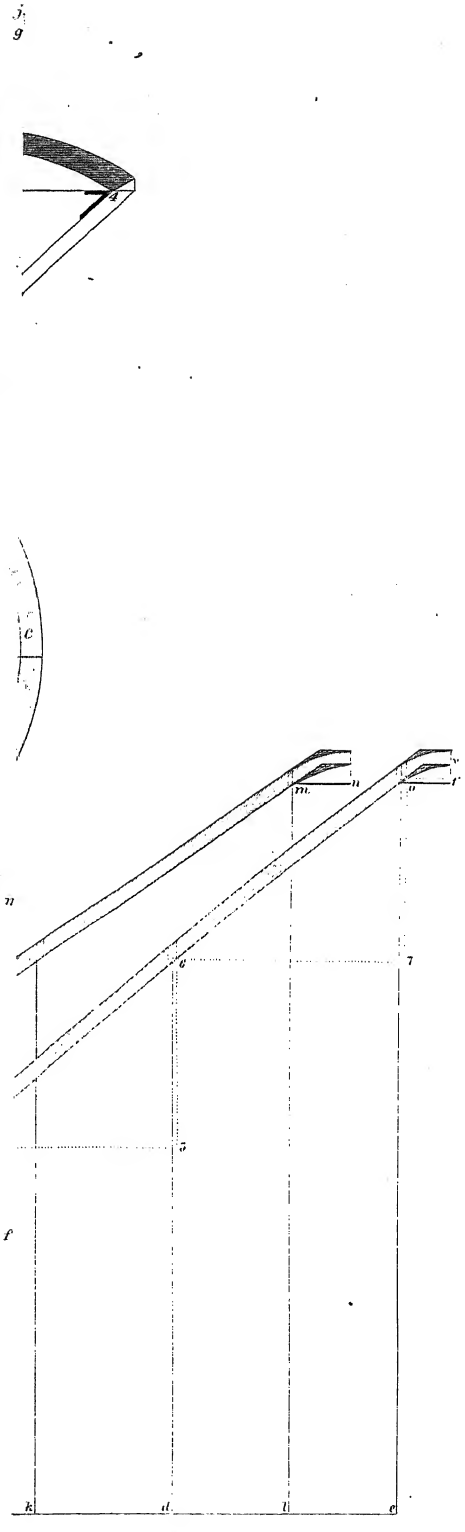
PLATE 20.

Exhibits the plan of a rail and scroll, the well-hole being an eccentrical form, the scroll being drawn as Plate 16.

Fig. 1st, having 2, 3, 4, 5 and 6, as centres, commencing at 2, having 2 *p* and 2 *r* as radii, describe the quadrant *c e* of the concave and *p r* of the convex, which form the first quadrant; then from the centre 3, having 3 *r* and 3 *t* as radii, describe the quadrant *e g* of the concave and *r t* of the convex, which form the second quadrant; then from the centre 4, having 4 *t* and 4 *i* as radii, describe the segment *g i* of the concave and *t i* of the convex, which form the first segment; then from the centre 5, having 5 *i* and 5 *w* as radii, describe the segment *i j* of the concave and *i w* of the convex, which form the second segment; then from the centre 6, having 6 *w* and 6 *z* as radius, describe the quadrant *j m* of the concave and *w z* of the convex, which form the third quadrant. The manner of obtaining the stretch-outs *a b* (of the scroll) of *a c*, *c d*, of *c e*, *e f*, of *e g*, *g h*, of *g i*, *i j*, of *i j* and *j l*, of *j m* of the concave side; also *n o* (of the scroll) of *n p*, *p q*, of *p r*, *r s*, of *r t*, *t u*, of *t i*, *v w*, of *i w*, and *w y* of *w z* of the convex side of the several quadrants and segments and their application to the base, *a*, *c*, *e*, *g*, *j*, *k* and *m* of the concave, also *n*, *p*, *r*, *t*, *w*, *x* and *z* of the convex side for the formation of the concave and convex falling moulds, as at figs. 2 and 3, the moulds being raised the height of 1 ½ risers above its base. In obtaining the joints and easings, the heights of the several joints for the formation of the face-moulds are the same as has been described in the preceding plates. It should be observed that the several distances from centres to centres are thus, from 2 to 3 equal to 2 inches, from 3 to 4 equal to four inches, from 3 to 5 equal to 6 inches, and from 6 to 6 equal to 4 inches; which gives the form to the well-hole.



R.Miller,Print

PLATE 21.

To draw the plan and elevation of a staircase, the well-hole being the frustum of a cone, also the moulds for the formation of the rail for the same.

Fig. 1. Let *a b* be the diameter of the lower and *c e* of the upper end of the conical frustum, divide the distance *a c* or the expansion of the frustum into four equal parts, then apply the distance equal to one of the parts each side of the centre of the diameter *a b* as *s t u v* which form a square, then each angle of said square being the centres as *s t u v* for each respective quadrant, then from the centres, *s*, of the first quadrant, *t*, of the second, *u*, of the third, and *v*, of the fourth, which produces the expansion of the frustum or well-hole, commencing at *a* and ending at *c*, which completes the concave side of the required plan; then set off the length of the tread which is from *a* to *d*, then from the same centres describe the convex side of the required plan, then from the centre of the diameter *a b* describe the circle from *f* through *h* to *f*, and divide the circle *f h* to *f* into the number of given parts there are intended to be treads (in this there are twenty), and from the points of division upon the outer circle *f h* to *f*, to the centre of the given plan, draw lines from the convex to the concave side of the given plan, commencing at *d a* and *c f*, which gives the size of each tread, and showing their gradual expansion.

To draw the elevation of the given plan, fig. 1, as at fig. 2, from the centre of the given plan, fig. 1, erect a perpendicular through *x* to *z*, fig. 2, then draw the base line *m n*, which being equal in length to the diameter *f h*, of the given plan, fig. 1; then erect *n h*, the height rod, which being divided into the number of parts there are intended to be risers (there being twenty treads, therefore it will require twenty-one

risers), then draw *h f*, parallel to *n m*, which being the height of the frustum for the stairs; then from the centre *x*, describe the semicircle *a b*, whose diameter is equal to the diameter, *a b*, fig. 1, or base of the frustum, also from the centre, *z*, describe the semicircle, *c e*, whose diameter is equal to the diameter, *c e*, fig. 1, or expansion of the frustum; then set off the distance from *a b* and *c e*, equal to the length of the tread, *a d*, fig. 1; then draw the lines *d f*, *a c*, *b c*, and *h h*, which give the stairs its conical form.

To draw the concave string of fig. 2, *and give it the spiral form.*

Divide the semicircles *a b* and *c e* into half the number of parts there are treads in the given plan, fig. 1, and let fall perpendiculars from each point of division to the base of each of the semicircles, *a b* and *c e*, as is shown in the diagram at *s t* and *u v;* then from each of the points upon the base, *a b*, draw lines to each of the points in the base, *c e*, as from *t* to *v*, which gives the face of each riser upon the concave string; the convex string is formed in the same manner, thus far describing semicircles from *d* to *k*, and *f* to *h*, from the centres *x* and *z*, and dividing them into the same number of parts as *a b* and *c e*, and from each of the points of division, let fall perpendiculars to the base *d k* and *f h;* then from the point of division upon the base *d k*, draw lines to each of the points in the base *f h*, which gives the face of each riser upon the convex string; then from each of the parts upon the height rod, *n h*, draw lines parallel to the base, *d k*, which gives the line of each tread from the concave to the convex string; then from the upper edge of each riser upon the concave and convex strings, set down the depth of each string, and through those points trace out the curve or lower edge of the string. The elevation of the rail is traced out in the same manner which is supposed to be placed upon the balusters, that it may retain its proper height from the upper edge of the concave string.

To draw the plan of the rail, as figs. 3 *and* 4, *for the given plan, fig.* 2.

Set up the height at *a*, fig. 2, equal to the height of the short baluster, as at *d o;* then draw *o a* to *b* parallel to the base *d k* at *q*, erect the perpendicular *q c* equal in

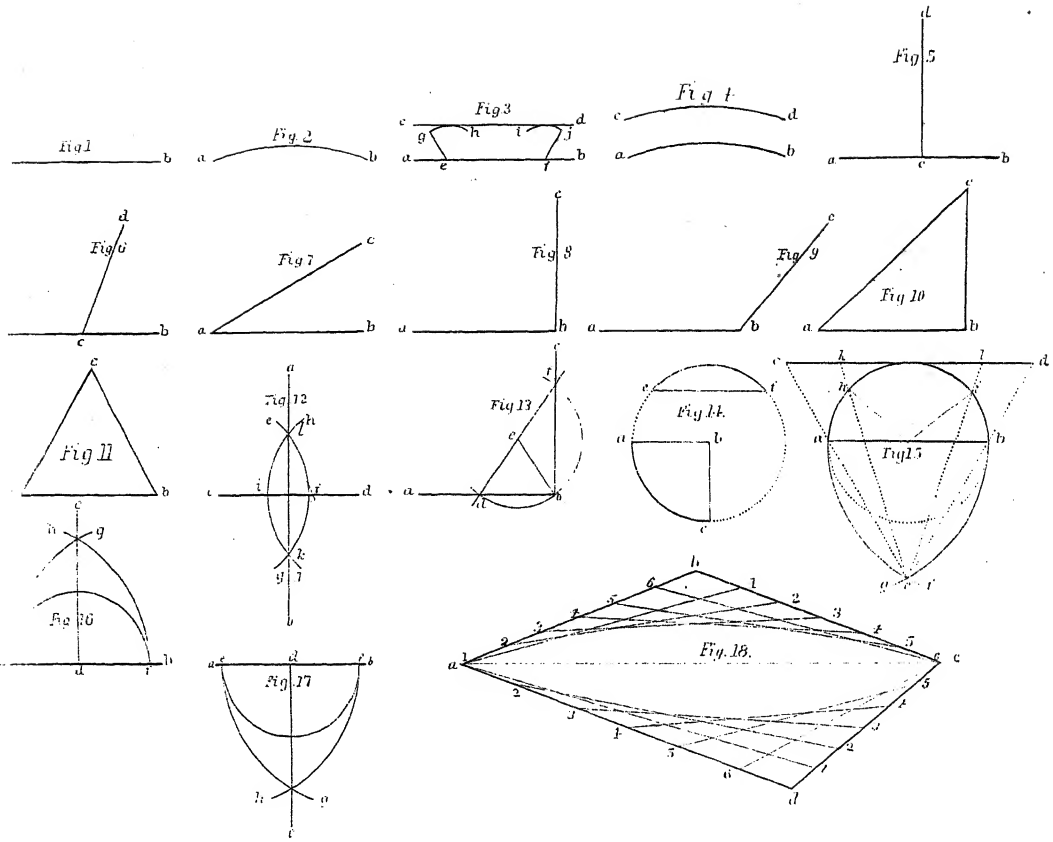
height to *n h*, the height rod, and draw *g c* to *e* parallel to *f h*, the line of the floor; then obtain the semi-diameter of the well-hole upon the line, *g c*, as from 5 to *i*, deducting the projection of the rail over the concave side of the concave string, and apply said distance from *c* to *z*, fig. 3, at *z;* let fall the perpendicular, *z y*, then obtain the expansion of the well-hole from *c* to *a*, fig. 1, and apply said distance from *q* to *a*, fig. 3; then from the centres *z* and *y* describe the semicircles *c e* and *a b*, then draw the lines *a c* and *b e*, which give the plan for the rail its conical form (the dotted line around the given plan, fig. 3, shows the projection of the rails over the concave edge of the concave string); then divide the perpendicular *y z*, fig. 3, into four equal parts, as 2 4 6, which lines being the diameter of the frustum at each given point; then subdivide each of these parts into two equal parts each, as *s t u v*, which lines being the semi-diameter of the frustum at each given point, let fall a perpendicular from the base of the frustum *a b* at *y*, through the given plan, fig. 4; draw the dotted line *m* through said plan parallel to the base, *a b*, of the frustum, fig. 3; then obtain the centres *s t u v* for each respective quadrant in the same manner as has been described in fig. 1; then take the distances equal to the semi-diameter at the several points as *s k* for the first quadrant, *t n* for the second, *u w* for the third, and *v x* for the fourth of fig. 3, and apply said distances from *s* to *k*, *t* to *n*, *u* to *w*, and *v* to *x*, fig. 4, also continue *s k* to *o;* then from the centre *s* describe the quadrant *k n* from *a*, from the centre *t* describe the quadrant *n w*, from the centre *u* describe the quadrant *w x*, and from the centre *v* describe the quadrant *x o*, also the segment *o p* from the centre *s*, for the concave side of the rail; then set off the middle of the given plan, and from the same centres describe the width of the rail upon the convex side of the given plan from *g* around to *j*, *j* to *m*, and *m* to *n;* then obtain the stretch-out of each respective quadrant and segment, *A*, *B*, *C*, *D*, *E*, in the same manner as has been described in the preceding plates.

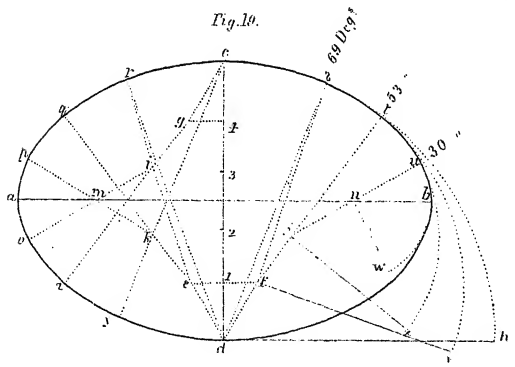
To draw the concave and convex falling moulds, as figs. 5 *and* 6.

Draw the base line, *g e*, then obtain the concave stretch-outs, fig. 4, of the several quadrants, *a b* of the first, *c w* of the second, *w d* of the third, and *e o* of the fourth,

and apply them upon the base, fig. 5, from *a b c d* to *e;* at *e* erect the perpendicular, *e o*, and let its height be equal to the conical side of the frustum *a c*, fig. 3; then erect the perpendiculars *b c* and *d*, fig. 5, and let their height be equal to *a* 2 *a* 4 and *a* 6, fig. 3; then draw the floor line, *o f*, equal in length to the stretch-out, *o f*, fig. 4, let *f v*, fig. 5, be equal to half a riser; then through those points upon the perpendiculars, from the base at *a b c d* and *e*, let the curve of the lower edge of the falling mould be traced; then set up the height of the newel, as from *a* to *b*, fig. 2, and draw *l l* parallel to *o a;* then take the distance *a l*, fig. 3, and apply it from *a* to *l*, fig. 5; draw *l l* parallel to its base, *a b;* then set up the width of the mould, which being equal to the depth of the rail, and draw the upper edge parallel to the lower and form the easing at each end of said mould, the joints being formed, the perpendiculars and base lines being drawn for each respective piece, as 1 2, 3 4, 5 6, 7 *o* and *f r*, which completes the concave falling mould. The convex falling mould, fig. 6, is formed from the same corresponding points from the convex stretch-outs of fig. 4, as was fig. 5 from the concave stretch-out, fig. 4; also the manner of obtaining the curvature for its formation, the manner of obtaining the easings and locating the joints on the convex mould, are the same as has already been described.

To form the face-moulds, *A B C D* and *E*, from the parts *A B C D* and *E*, fig. 7, and the manner of obtaining the heights from the concave falling mould, fig. 5, for the formation of the face-moulds, are the same as has already been described, which will be seen by the corresponding points, as 1 2, 3 4, 5 6, 7 *o* and *f v*. It should be observed that the given plans of figs. 4 and 7 are the same, and that the curvature of the concave and convex falling mould, figs. 5 and 6, is caused by the expansion of the well-hole. The angle at *o*, fig. 2, shows where the bevel may be obtained, to apply upon the part of the string where the tread rests, which allows the tread to lie parallel with the base of the given plan.





Engd by J.H.Atwood N.Y.

PLATE 22.

PRACTICAL GEOMETRY.

Definitions.

1. A *right* or *straight line* is the shortest that can be drawn between two given points, *a b*, fig. 1.

2. A *curve-line* is a line which is not straight, as *a b*, fig. 2.

3. *Parallel lines* are straight lines that are drawn equidistant from each other, as *a b* and *c d* of figs. 3 and 4.

4. An *angle* is the space intercepted between two lines intersecting each other, whether right or oblique.

5. *Right angles* is where one line meets another so as to make the angles on each side equal; then each angle is called a right angle, as *a c d* and *b c d*, fig. 5, and the line *c d* which rests on the base *a b* at *c* is called a perpendicular.

6. *Oblique angles* is where one line meets another, so as not to make the angles equal on each side, as *a c d* and *b c d*, fig. 6.

7. An *obtuse angle* is greater than a right angle, as *a c d*, fig. 6.

8. An *acute angle* is less than a right angle, as *b c d*, fig. 6.

Examples—*a b c*, fig. 7, is an acute angle, *a b c*, fig. 8, is a right angle, and *a b c*, fig. 9, is an obtuse angle.

9. A *triangle* is a space enclosed by three right lines, as *a b c*, fig. 10.

10. A *right angled triangle* is that which has one right angle, as *a b c*, fig. 10, *a b* is the base, *b c* the perpendicular, and *a c* the hypothenuse.

11. An *acute angled triangle* is a triangle which has all its angles acute, as *a b c*, fig. 11.

12. An *equilateral triangle* is a triangle having all its sides equal, as *a b*, *b c* and *c a*, fig. 11.

13. A *circle* is a plain figure formed by one uniform curved line, which is its circumference, as fig. 14.

14. The *diameter* of a circle is a right line drawn through the centre, and terminated by the circumference, as *a b*, fig. 15.

15. A *chord* is a right line which joins the two ends of any arc of a circle, as *e f*, fig. 14.

16. A *semicircle* is one-half of a circle, being divided into two equal parts by its diameter, as *a b*, fig. 15.

17. A *segment* of a circle is that portion cut off by a chord, as *e f*, fig. 14.

18. A *quadrant* is the fourth part of a circle, as *a c*, fig. 14, contained between two radii, forming a right angle at the centre, as *b c*, and *b a*.

19. An *arc* is any portion of the circumference of a circle, as *e f*, fig. 14.

20. A *radius* is the semi-diameter of a circle, as *b a*, and *b c*, fig. 14.

21. A *sector* is the portion of a circle formed by two radii, as *j a h*, or *j h i*, or *j b i* to fig. 15.

Problem 1.

At a given distance parallel to a straight line, as a b, fig. 3, *to draw a straight line, as c d.*

In the given straight line, *a b*, take any two points, as *e f;* then with the point of the dividers at *e* and *f* describe the arcs *g h* and *i j;* then draw the line *c d*, cutting the arcs *g h* and *i j*, then *c d* will be parallel to *a b*.

Problem 2.

To bisect or divide a straight line by a perpendicular, as a b, to c d, fig. 12.

Take the distance greater than half *c d*, then with the point of the dividers at *c*, describe the arc *e f g*, also at *d* describe the arc *h i j;* then through the bisecting points of the arcs at *k* and *l*, draw *a b*, which will be perpendicular to *c d*.

Problem 3.

To erect a perpendicular at the end of a straight line, as b c, from the base a b, fig. 13.

Take any point above the line *a b*, as *e*, and with the radius, *e b*, describe the arc *d b f;* draw the line *d e* straight through to the arc at *f;* then from the point *b*, draw the line *b c*, through the bisecting points at *f;* then *b c* will be perpendicular to the base *a b*.

Problem 4.

To erect a perpendicular from any given line, as d c from a b, fig. 16.

From the point *d* describe the arc *e f;* then having *e* and *f* as centres, describe the arcs *e g* and *f h;* then from the point *d* draw the line *d c* through the bisecting points *g h*, and *d c* will be perpendicular to the base *a b*.

To let fall a perpendicular from any given line, as *d c* from *a b*, fig. 17. Proceed in the same manner as has been described in fig. 16.

Problem 6.

In any given angle, as a b c, or a d c, fig. 18, *to describe a curve by straight lines.*

Let *a b c* or *a d c* be the given angle; then divide *a b* or *a d* into six equal parts also *b c* or *d c*, as is shown in the diagram; then from the point 1, nearest the angle *b* or *d*, upon one side draw lines to the farthest on the other side, as 1 to 1, 2 to 2, 3 to 3, and so on until the whole be completed.

This Problem is of much use in forming the curvature or easing in the angles for the rail and stairs.

Problem 7.

To find a right line which is nearest equal to the semi-circumference of a circle, as c d the tangent is to the semicircle a b, fig. 15.

Let *a b* be the diameter, having *a b* as centres, describe the arcs *a f* and *b g*, and at the bisecting point of *g f*, at *e*, draw straight lines from the point *e* through *a* and *b* to *c* and *d;* then draw the tangent line *c d* parallel to the diameter or base *a b:* then *c d* will be nearest equal to the semicircle part, *a b*. To obtain the lengths of the several segments *a h*, *h i* and *i b* upon the tangent line *c d*, from the point *c* draw lines through *h* and *i* to the tangent *k l;* then *c k*, *k l*, *l d*, upon the tangent, will be equal to *a h*, *h i* and *i b* of the several segments. By this process the student will perceive that any portion of the circle may be transferred to a straight line.

Problem 8.

To form an ellipsis by means of segments of circles, as fig. 19.

Let *a b* be the transverse, and *c d* the conjugate axis, having *d* as centre, with *d c* and *d h* as radius, describe the quadrant *c h;* then from the centre *d* draw the radii *d s* at an acute angle of 69 degrees from *d h*, the base; then divide the conjugate axis *c d* into five equal parts; then through the point 1, draw *e f* parallel to the transverse axis *a b;* then form an equilateral triangle, as *d e f;* then having *f* as centre with *f s* and *f v* as radii, describe the quadrant *s v;* then from the centre *f* draw *f t* at an angle of 53 degrees from *d h*, the base; then take the distance *d* 1, and apply said distance from *f* to *i* upon the line *f t;* then having *j* as centre, with *j t* and *j x* as radii, describe the quadrant *t x;* then from the centre *j* draw *j u* at an angle of 30 degrees from *d h*, the base; then at the point of intersection with *j u* to the transverse axis, *a b*, will be the centre *n;* then having *n* as centre, with *n u* and *n w* as radii, describe the quadrant *u w:* then the segment *c s* of the quadrant *d c h*, and the segment *s t* of the quadrant *f s v*, and the segment *t u* of the quadrant *j t x*, and the segment *u b* of the

quadrant *n u w*, which forms one fourth part of the ellipsis from *c* to *b*, the parts *b d*, *d a* and *a c* are formed, and the centres obtained in the same manner as has been described.

It should be observed that to form the moulds for the rail of an elliptic stairs it is necessary to obtain the stretch-out of the segments of each respective quadrant, in the manner as has been described in the preceding plates, before the moulds can be executed.

THE END.